Summaries of science objectives

- nocturnal SBL and the LLJ
- nocturnal MCS dynamics and microphysics
- bores
- nocturnal convection initiation
- data assimilation, NWP, & prediction

nocturnal SBL and the LLJ

Petra Klein et al., OU	**LLJ in the SBL structure, evolution, and interactions with mesoscale atmospheric disturbances**
Qing Wang, NPS Todd Sikora, Rich Clark, Millersville U.	**SBL processes and their interaction with nocturnal convective activities over the Great Plains**
Tom Parish, U. Wyoming	**Airborne measurements of the LLJ in PECAN**
John Hanesiak, U. Manitoba	**SBL/LLJ evolution and elevated convection initiation**
Belay Demoz et al., Howard U. and GSFC	**Ground-based lidar profiling of the thermodynamic and dynamic structure of the SBL in PECAN**

Low-level jets in the nocturnal stable boundary layer: structure, evolution, and interactions with mesoscale atmospheric disturbances

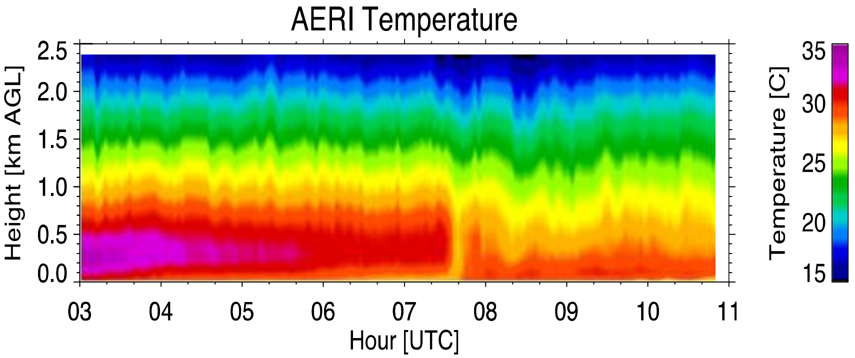
Petra Klein, Phillip Chilson, Evgeni Fedorovich,
Wayne Feltz, Alan Shapiro, and David Turner

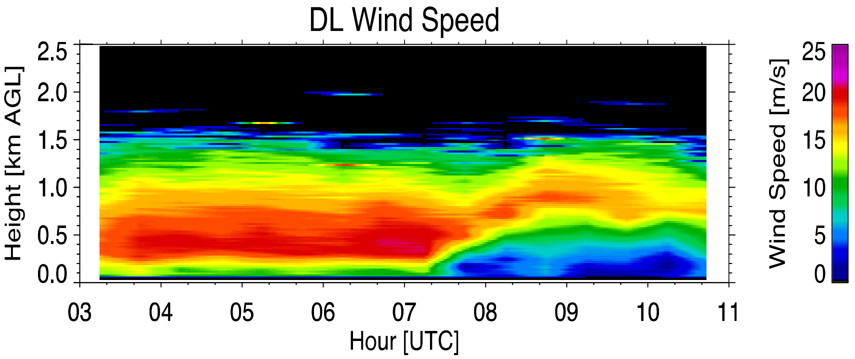
School of Meteorology, University of Oklahoma
NOAA National Severe Storms Laboratory
Space Science Engineering Center, University of Wisconsin - Madison

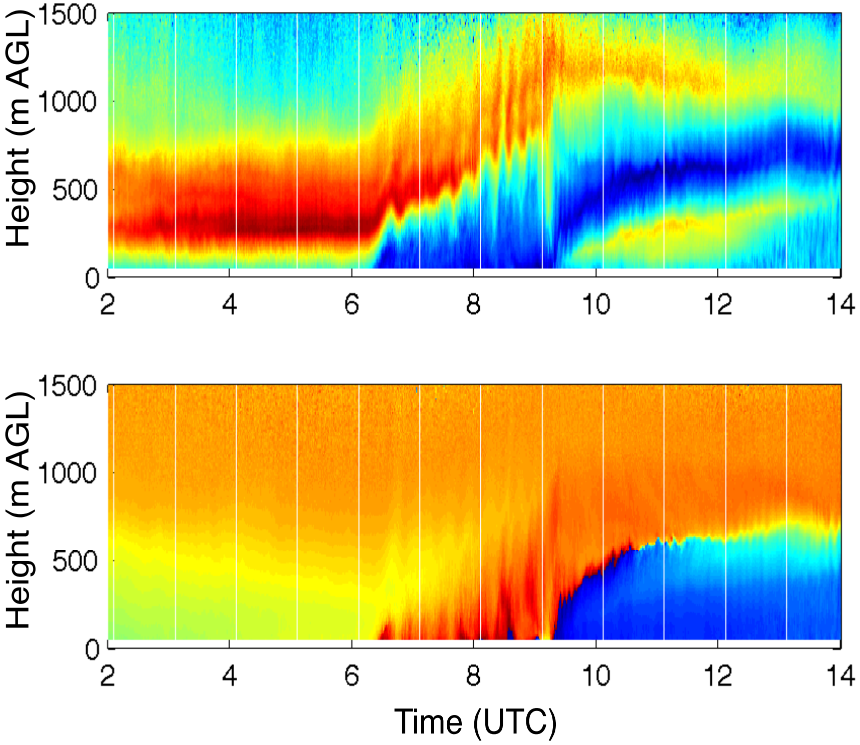
Objectives

- Investigate the mechanisms affecting the **formation, evolution, and structure of NLLJs** over gently sloping terrain in relation to night-time convection
  - Observations from mobile and fixed PECAN sites
  - In conjunction with analytical and numerical modeling
- Factors investigated include:
  - effects of terrain slope,
  - thermal SBL structure,
  - synoptic-scale forcing,
  - role of interactions between NLLJs and mesoscale atmospheric disturbances in the initiation and development of night-time convection.

Observations







Understanding Nocturnal Low-level Jet and Stable Boundary Layer Processes Associated with Convection Initiations

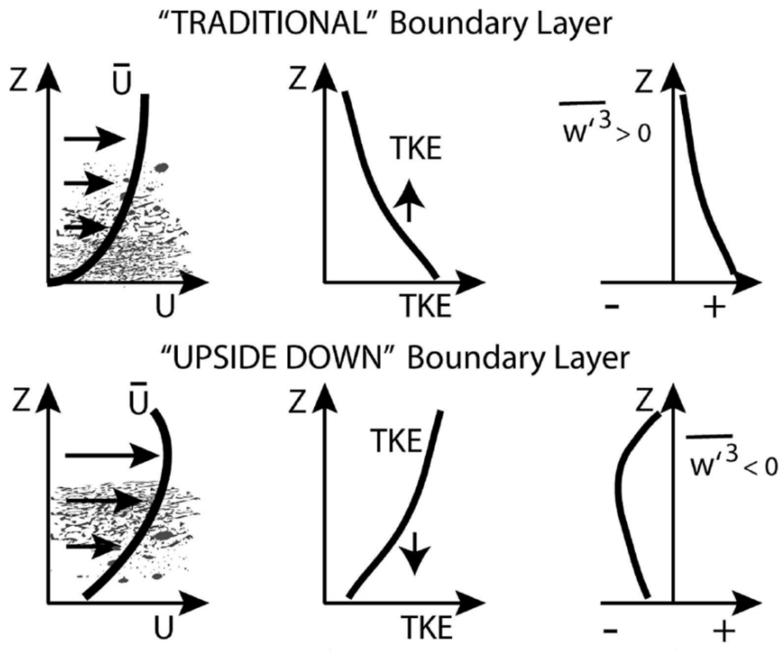
A Collaborative Effort

Qing Wang
Department of Meteorology
Naval Postgraduate School
Monterey, CA

Richard Clark and Todd Sikora
Department of Earth Sciences
Millersville University
Millersville, PA

18-month effort for field measurements and data QC

NPS/MU Research Objectives



(from Banta et al. 2006)

Scientific Question: What are the nocturnal evolution of boundary layer momentum, heat and water vapor transport that supports convection development?

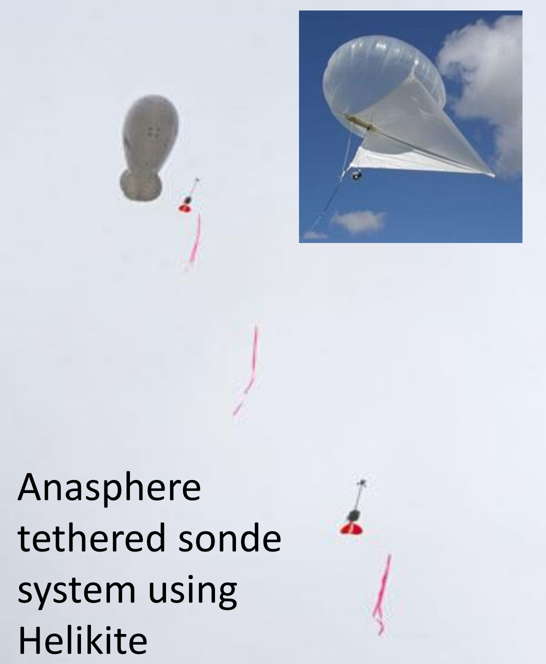
- Quantify the evolution of nocturnal low-level-jet (LLJ) and SBL turbulence
- Identify the role of the low-level jet (LLJ) and its evolution in the development of SBL turbulence
- In events of bores and density currents, quantify the interactions among bores/density currents, LLJ, and SBL turbulence
- Data QC and submission and collaboration with other PECAN measurements and modeling efforts

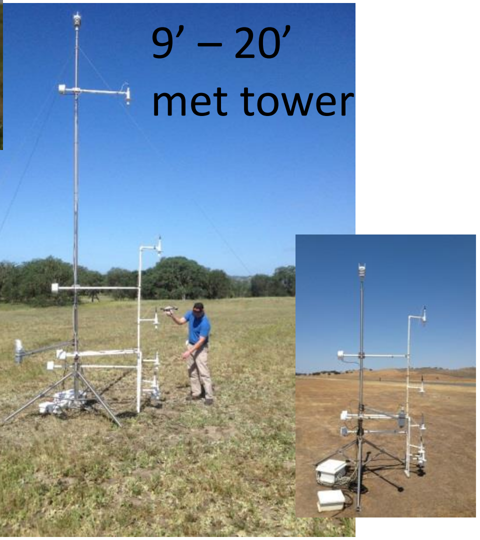
Uniqueness of NPS/MU Measurements

- Turbulence measurements made simultaneously with the mean field
- In situ measurements concurrent and co-located with PISA remote sensors

NPS Planned Measurements

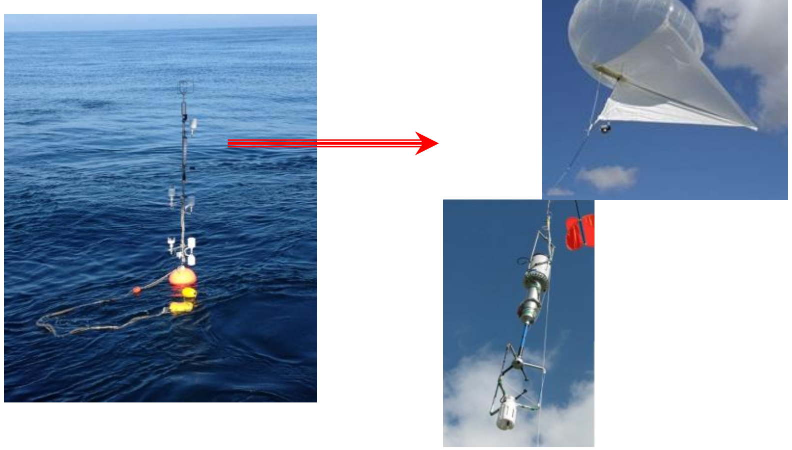

40’ flux tower


Anasphere tethered sonde system using Helikite


9’ – 20’ met tower

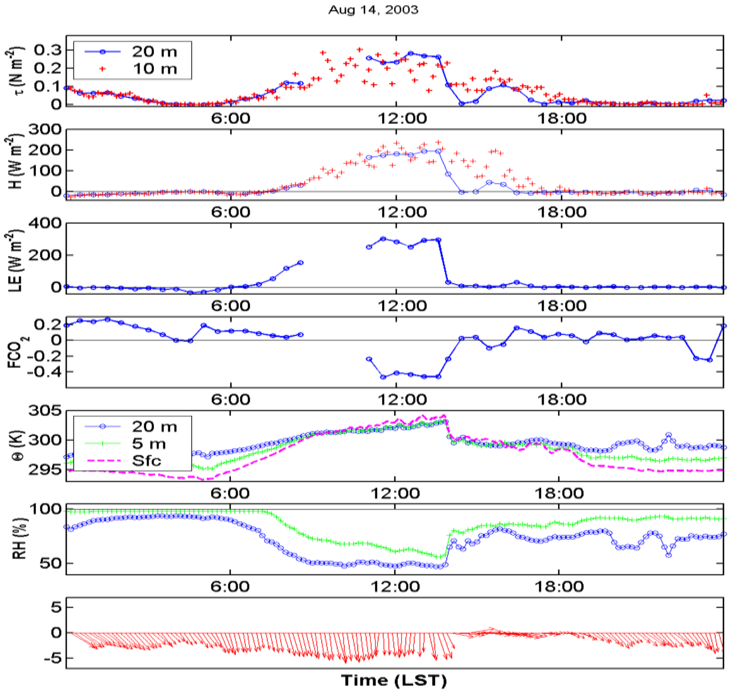

sodar

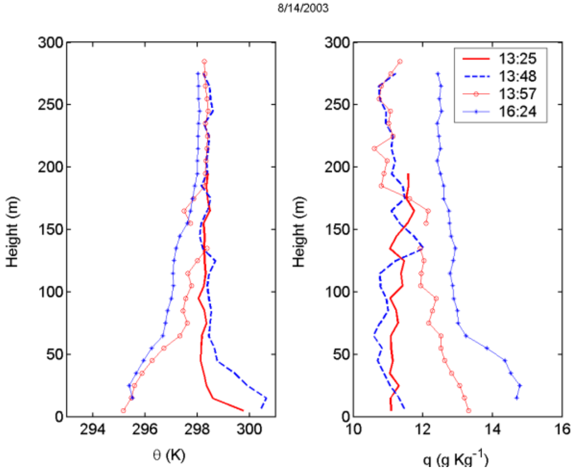
Under Development:



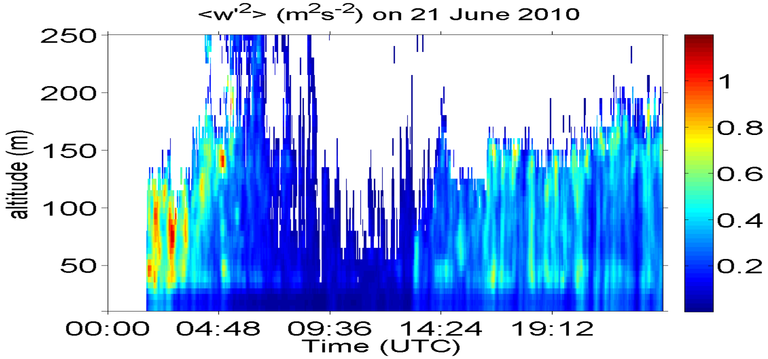
Examples of Previous NPS Measurements

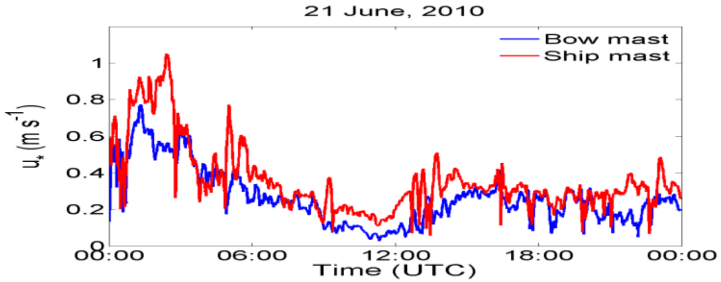
Boundary Layer Response to Change in Wind Direction





Boundary Layer Turbulence Profiles From Sodar





Millersville U. Assets

Vaisala TTS-111
Tethersondes

Surface Flux Tower,
Various Instruments

Vaisala MW41 Sounding
System, RS92-SGP Sondes

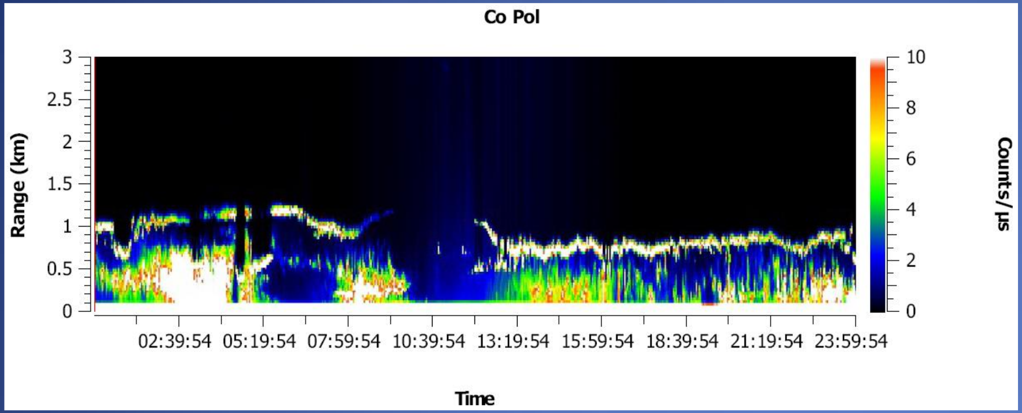
Dedicated Undergraduate
Students

SigmaSpace
MPL4

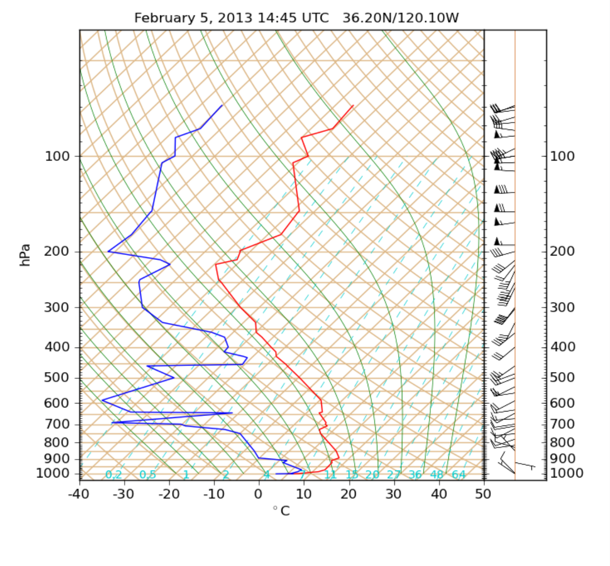
Scintec MFAS with
RASS extension

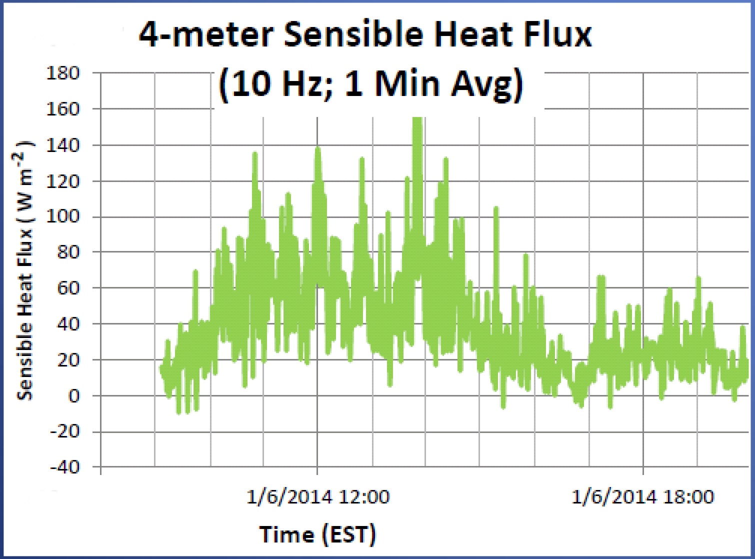
Examples of MU Measurements

MPL4

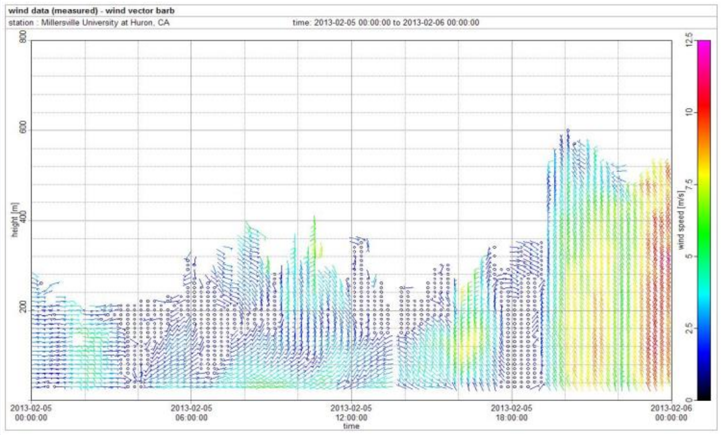


Vaisala MW41 Sounding System





Surface Flux Tower



MFAS

Airborne Measurements of the LLJ Dynamics

Thomas R. Parish
Bart Geerts
Zhien Wang

Department of Atmospheric Science
University of Wyoming

Equation of Motion:

$$\frac{d\vec{V}}{dt} = -\frac{1}{\rho}\vec{\nabla} p - g\vec{k} - 2\vec{\Omega} \times \vec{V}$$

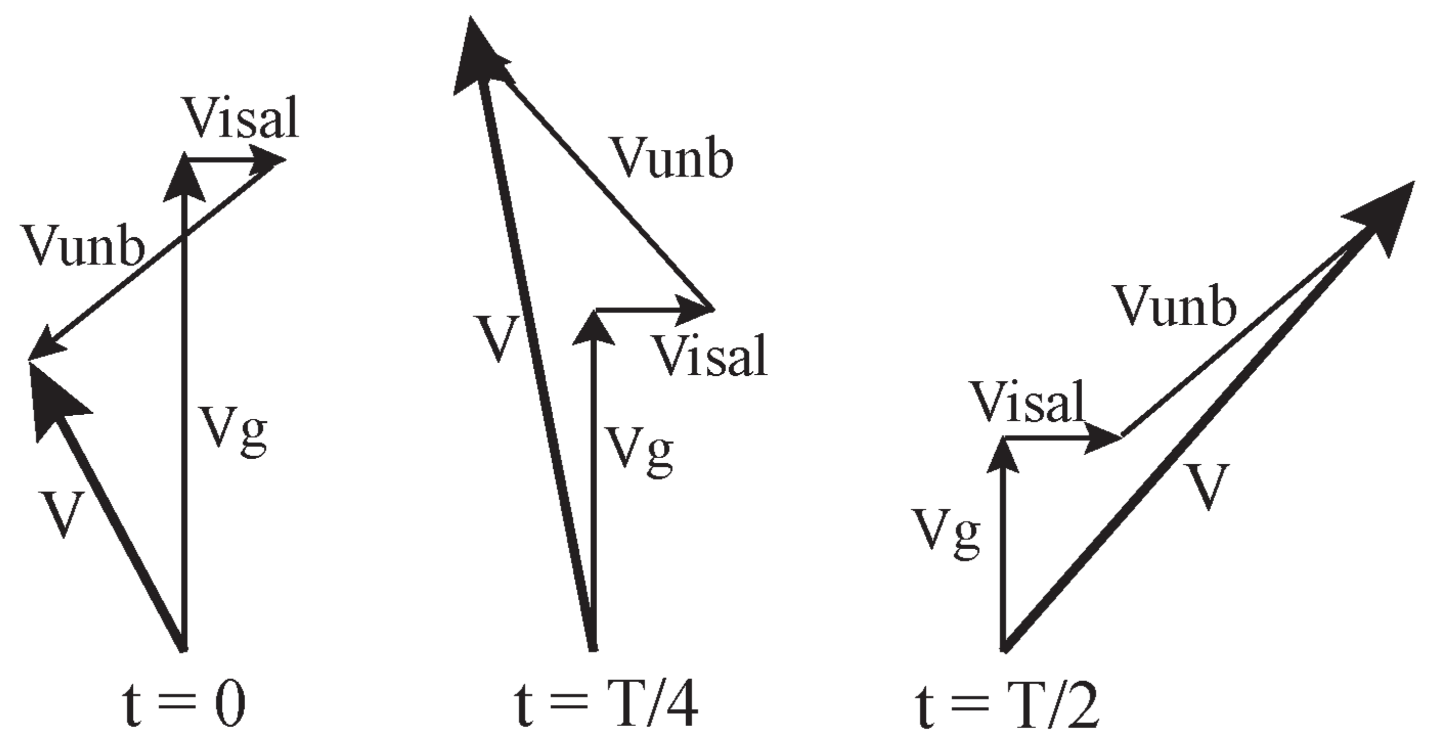
Pressure Gradient Force

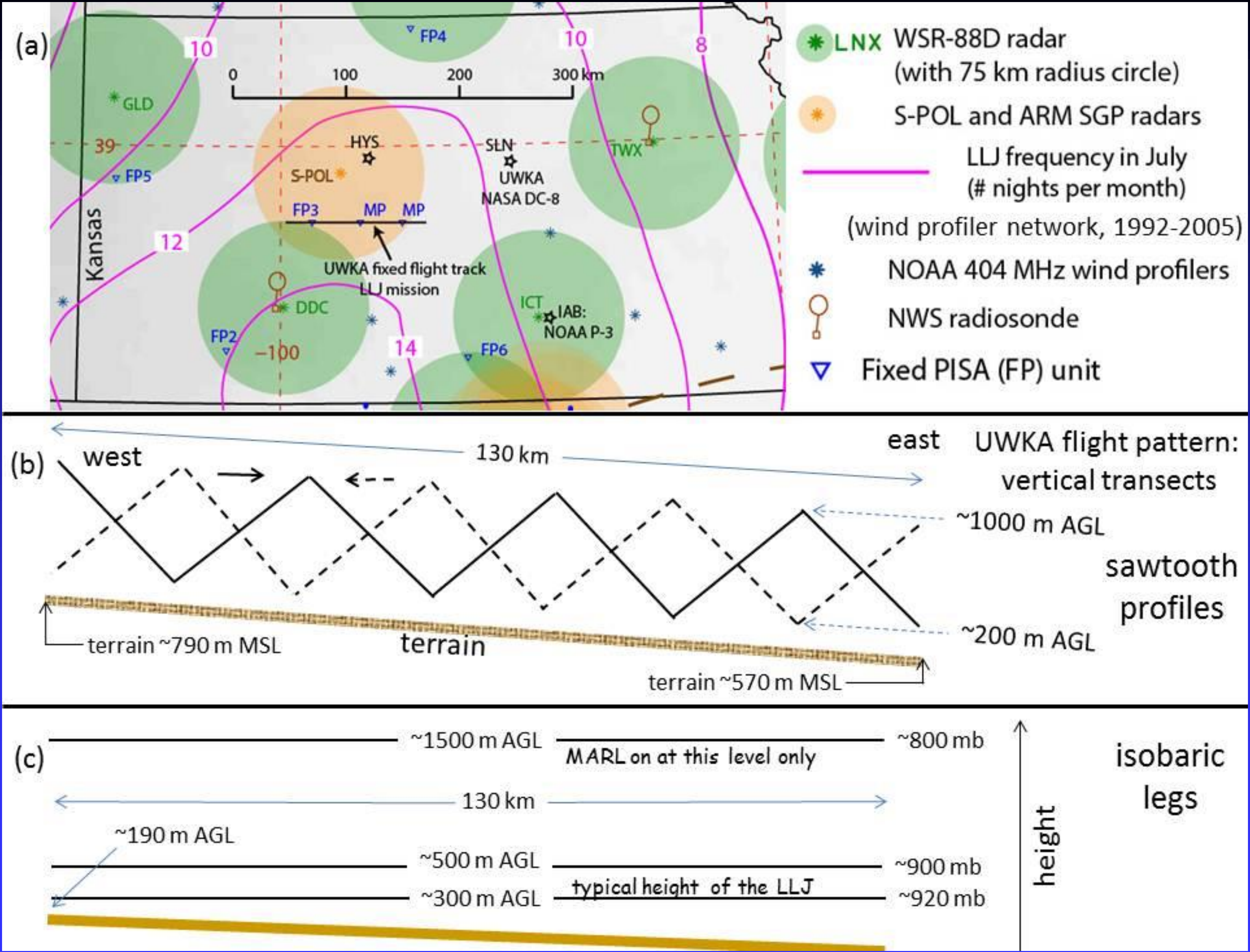
Coriolis Force

Great Plains Low Level Jet

- Dynamics of Nocturnal Jet
- Role of Thermal Forcing

Great Plains Low-Level Jet




(a)
10
10
8
0
100
200
300 km
FP4
GLD
39
FP5
HYS
S-POL
SLN
UWKA
NASA DC-8
TWX
FP3
MP
MP
Kansas
12
UWKA fixed flight track
LLJ mission
DDC
FP2
−100
14
ICT
IAB:
NOAA P-3
FP6
LNX WSR-88D radar
(with 75 km radius circle)
S-POL and ARM SGP radars
LLJ frequency in July
(# nights per month)
(wind profiler network, 1992-2005)
NOAA 404 MHz wind profilers
NWS radiosonde
Fixed PISA (FP) unit
(b)
west
130 km
east
UWKA flight pattern:
vertical transects
~1000 m AGL
sawtooth
profiles
~200 m AGL
terrain ~790 m MSL
terrain
terrain ~570 m MSL
(c)
~1500 m AGL
~800 mb
MARL on at this level only
130 km
~190 m AGL
~500 m AGL
~900 mb
~300 m AGL
typical height of the LLJ
~920 mb
height
isobaric
legs

PECAN Plans – U Manitoba

J. Hanesiak

University of Manitoba

PECAN meeting May 12-14, 2014

Research Questions

- How does the PBL evolve from late afternoon to overnight period, including the LLJ, within active and non-active MCS regions?
  - Relation to the important inflow region / level?
- What role does the LLJ (and associated moisture transport) play in ECI events (positive and/or failed) with respect to fronts?
  - LLJ magnitude and nose location
  - other convergence regions
- How (well) does the GEM-regional portray elevated convective events?
- How can PECAN results be transferred to Canadian Prairie events?
  - CCRN activities in SK as well as operational products for environment comparisons

Instruments

- UM-supplied 2 x MP3000's and 2 x Doppler wind lidars (one scanning system) at 2 fixed PISA sites
  - Real-time possible if hardwire internet is available
  - Can create ftp script to send data to a server
  - Lidars have quick-look images available
- Other fixed and mobile PISA's
- Available ground-based radars
- Aircraft data (including remote sensors)
- Lightning (CC and CG), satellite, analyses and model data

Real-Time Data

- From all sounding sites (mobile if possible) (CIN/CAPE/most uncapped CAPE for sfc and elevated parcels) – profilers and sondes
- Ground-based radars (VAD/RHI)
- Wind profilers
- Aircraft?
- Model output fields – there may be many !
- How/where to look at real-time data?
- In-field cell data sticks?

Belay Demoz, Howard U.
Bruce Gentry, Dave Whiteman, NASA Goddard
Dave Turner, NSSL

Ground-based Lidar Profiling of the Thermodynamic and Dynamic Structure of the SBL in PECAN

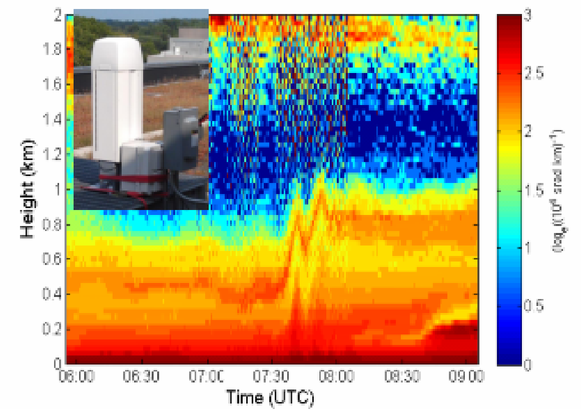
Fixed PISA2: Proposed instrumentation

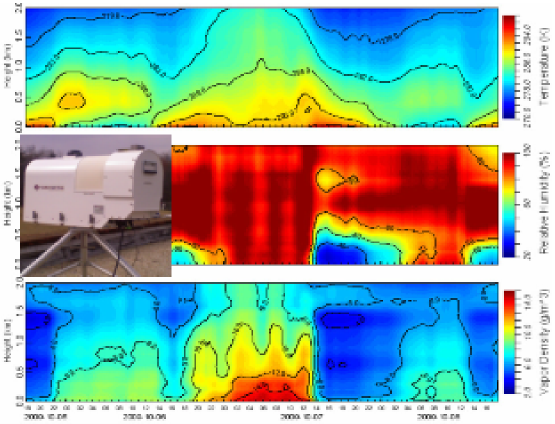
List of proposed instrumentation at FP2

Inst.	Quantity	frequency	Ops.	Owner
MWR	T, q, IPW, Surface met	2min, 50m - 250m	Continuous	HU
CL51	PBL, aerosol	15sec		HU
Leosphere	U, V, W	1min or less		HU (lease)
Sonde	T, RH, P, U	3hrly max.		HU
ALVICE	q, T, Sur.Met., Sonde, GPS, aerosol	ALVICE: 1-min, 30m; GPS: 30min; sonde as needed	Coordinated IOP	Contingent on NASA funding
GLOW	U, V, dir., aerosol	30m and up to 3min in time		

Note:

Funding for the NASA ground assets has not been secured and chances are getting slim by the day. In light of the limited funds available in NASA - a question that has been asked is if PECAN has a preference for the ground or DC-8 assets.



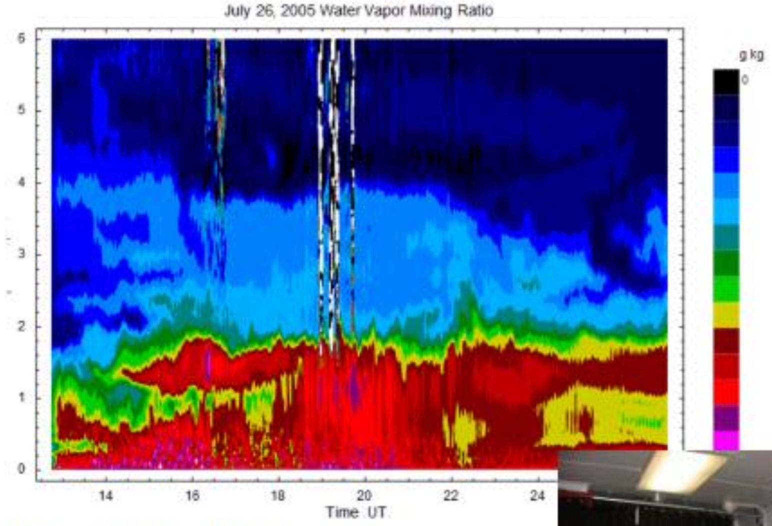


Demoz/NSF

- *Provide data to PECAN (see FP2 instrument table)*
- *Characterize moisture/wind (nighttime, transient waves, Bore, etc)*
  - *How often do they occur? How do they modify the lower stability?*
  - *Build archive/statistics on transient waves.*
  - *Demonstration of ceilometer network for Nighttime CI.*
  - *Intense moisture lifting: why some cause CI and others don't?*
- *Day-night and night-day PBL transition*
  - *LLJ events and role of NBL stability?*
    - *Leosphere/GLOW, MWR/ALVICE,Ceilometer, Sonde*
    - *Continuous measurements of moisture, temperature, wind and PBL*
  - *Contrast with NE-LLJ events and effects in PBL evolution*
    - *Is there any difference in the structure, and evolution of the LLJ that frequent the NE-US and the PECAN Domain*
    - *King Air (Raman at night), Leosphere/GLOW, MWR/ALVICE,Ceilometer, Sonde*
    - *Continues regional measurement from all is preferred here.*
  - *Examine the NBL (stability, elevated CIN, etc) during nighttime transient events.*

ALVICE Mobile Laboratory

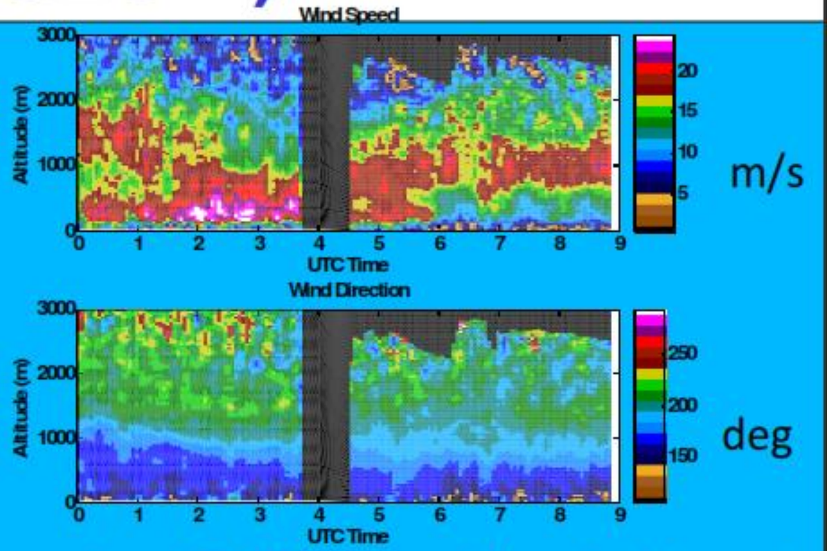
- Accepted as mobile reference within NDACC in 2010
- Unique set of measurements for atmospheric characterization. Focus on water vapor
  - Raman water vapor, aerosol, temperature lidar
    - extending development of Raman water vapor lidar at GSFC dating back to 1980
  - launch capability for
    - Vaisala RS92
    - Intermet
    - Cryogenic Frostpoint Hygrometer
  - GPS for total column water
  - Ventilated surface reference station for NIST traceable surface data useful for radiosonde accuracy studies
  - Independent calibration capability under development (NPP post-doc)



(Top) First ground-based measurements of the ALVICE/RASL system. Solar noon at 1800 UT with SZA of 20^0. (Right) Interior view of the ALVICE instrumentation.

(Above) CFH and RS92 preparation and launch. (Right) surface reference system for pre-launch sonde characterization

Goddard Lidar Observatory for Winds (GLOW)



Time series of GLOW lidar profiles of wind speed and direction from IHOP_2002. June 20, 2002.

Data Products:

- Radial wind speed profiles
- Wind speed and direction profiles derived from multiple LOS
- Useful altitude range- 0.1 to 30 km
- Minimum range res- 45 m
- Azimuth/Elevation range- 0-360 deg/ 0-90 deg
- Velocity Accuracy (typ)- 0.3 to 5 m/s (signal dependent)

Enhanced laser performance and improved receiver will result in x20 improvement in temporal/spatial resolution for PECAN vs IHOP Example: IHOP : 3 min, 100m , PECAN : 10 s, 100m resolution

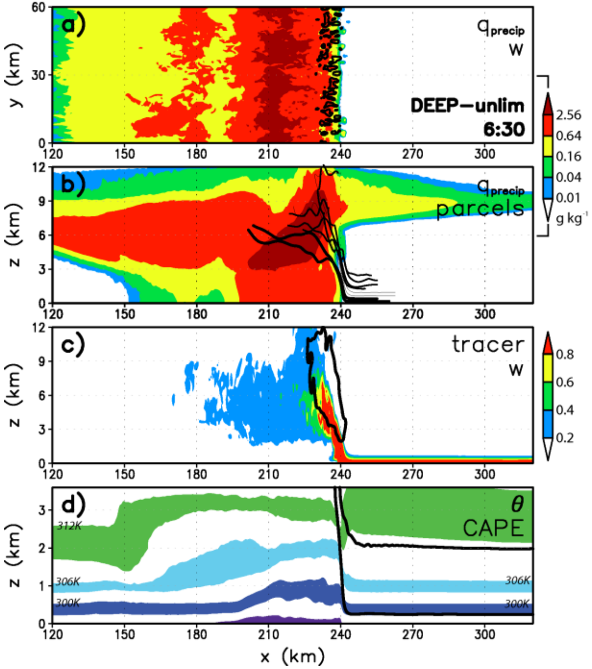
nocturnal MCS dynamics and microphysics

Conrad Ziegler, NSSL	**Lower-tropospheric cold pool generation & outflow processes associated with nocturnal MCSs**
Matt Parker, NCSU	**Understand lower tropospheric outflow processes associated with nocturnal MCSs**
Dave Jorgensen et al., NSSL	**NOAA P-3 microphysics and cold-pool dynamics of nocturnal MCSs**
Greg McFarquhar et al. U. Illinois	**Elevated nocturnal convection – the role of microphysical processes**
Karen Kosiba, Josh Wurman, CSWR	**Dynamics, Internal Structure, and Microphysical Evolution of Severe-Wind Producing Nocturnal MCSs and Transitioning Systems**
Stan Trier et al., NCAR	**Quantification of Mechanisms resulting in CI and MCS Sustenance** **Internal and External Factors Resulting in Successive MCS Activity**
Michael Bell, U. Hawai'i	**Convective and stratiform contributions to MCS longevity**

Ziegler et al.'s research interests

- ❑ Specific aim: *Understand lower-tropospheric cold pool generation & outflow processes associated with nocturnal MCSs*
  - ➢ Origins and mechanisms for MCS cold pool formation & maintenance
  - ➢ Transition process from sfc-based to elevated convection & cold pool
  - ➢ Influence of stability & shear in & above the nocturnal SBL

cold-pool-driven

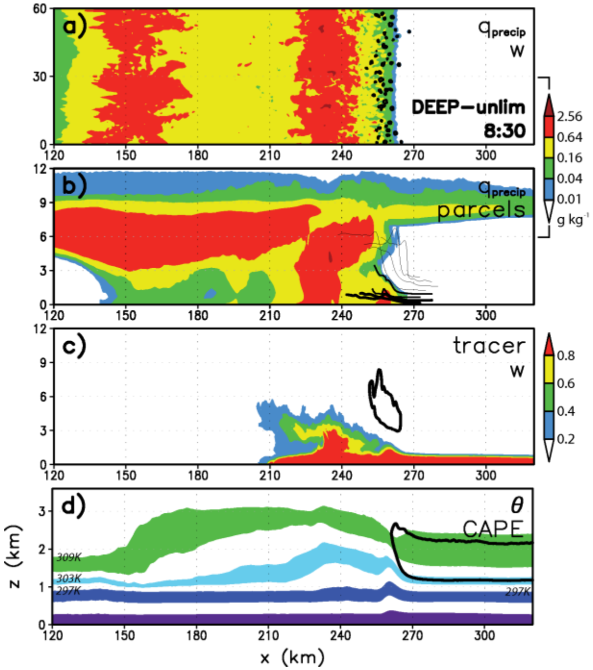


Plan view (a) and cross-sections (b-d) of a simulated "nocturnal" MCS (adapted from Parker 2008)

Left panel: cold pool-driven (earlier)

Right panel: bore-driven (later)

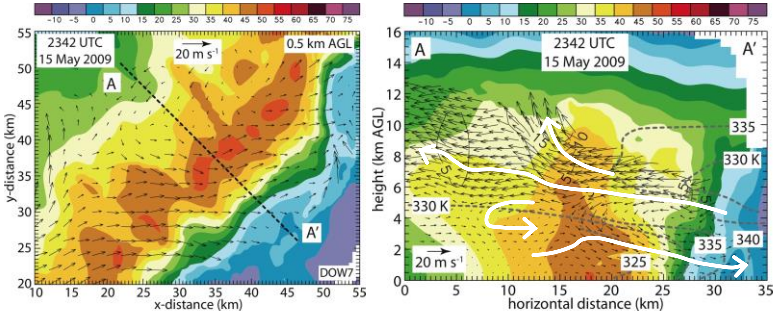
bore-driven



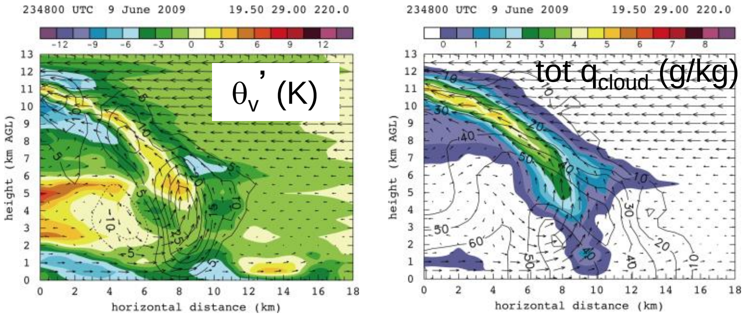
Ziegler et al.'s proposed research methods

- ❑ *Radar & state synthesis of PECAN observations*
  - ➢ Pre-MCS environment
  - ➢ Internal MCS flow fields
  - ➢ MCS outflow intensity, structure, & trajectories

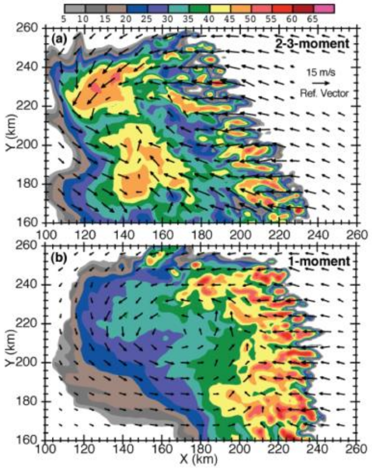
multi-Doppler ("over-determined DD")



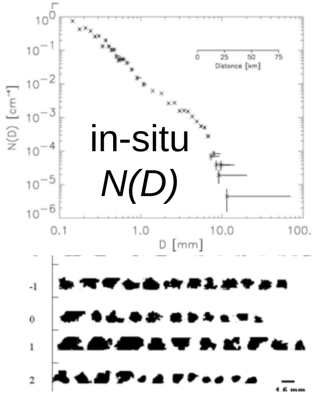
- ❑ *Diabatic Lagrangian analysis of PECAN obs*
  - ➢ Internal MCS temp/vapor & cloud/precip fields from trajectory-based kinematic cloud model



- ❑ *Process study simulations based on PECAN obs*
  - ➢ Initial conditions & validation from PECAN obs
  - ➢ Sensitivity to microphysics
  - ➢ Sensitivity to evolving pre-MCS stability and wind profiles



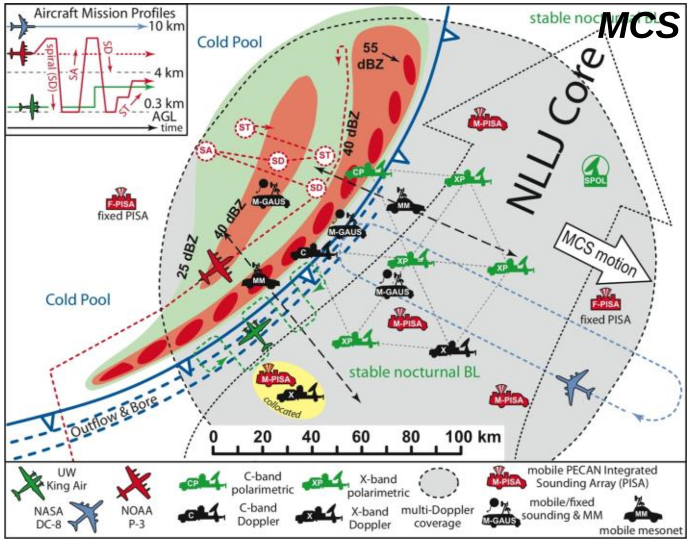
Left: Plan views of a simulated MCS (Mansell 2013)

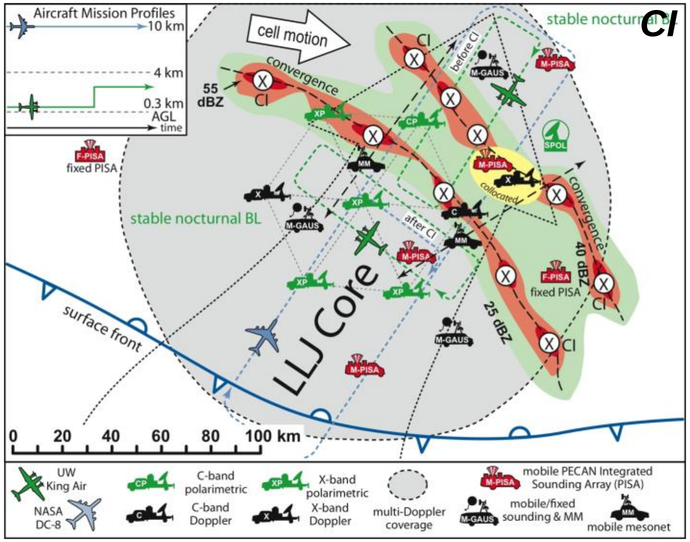


(McFarquhar et al. 2007)

Ziegler et al.’s data collection priorities

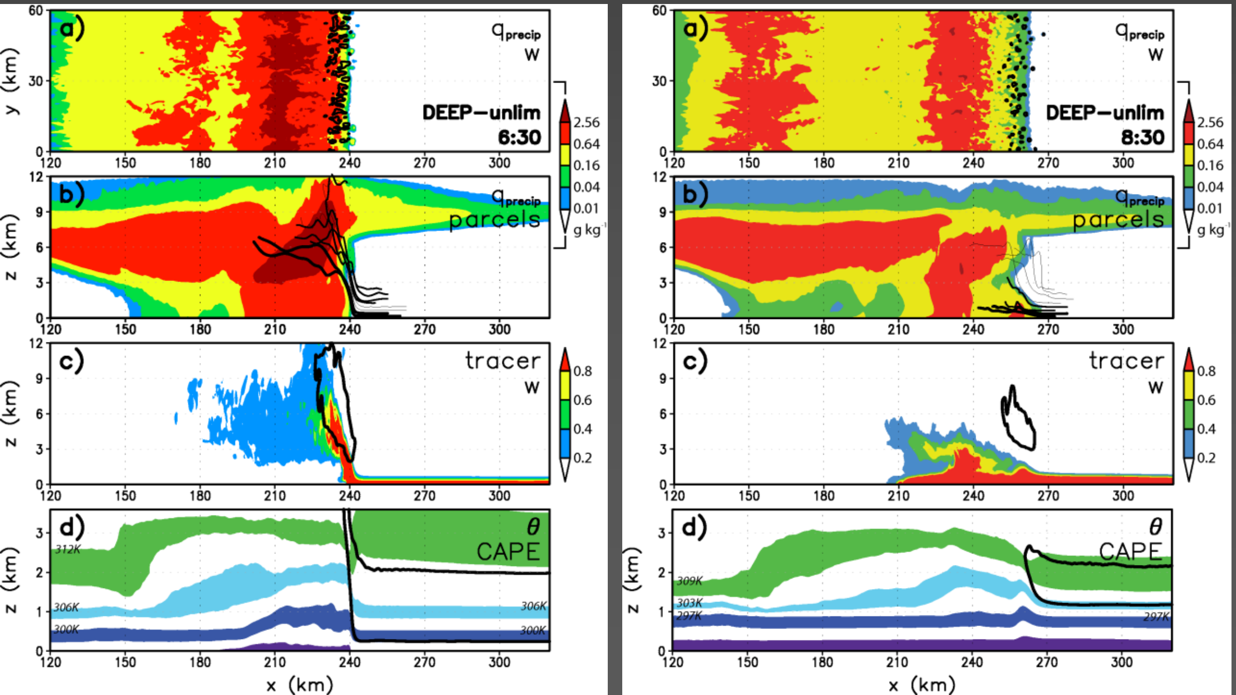
- ☐ *Most important platforms*
  - ➢ Mobile radars/P-3: high-res MD winds, 5-min (MCS) and 10-min (clear-air) volumes
  - ➢ Mobile Soundings: in convective/stratiform regions and environment
  - ➢ Surface obs: ahead, through, behind convective/stratiform regions
  - ➢ King Air, PISAs, S-POL, and DC-8 also useful when converged on MCS or CI
- ☐ *Preferred sampling methods (primarily MCS missions, also widespread CI)*
  - ➢ Start measurements at ~ sunset to capture nocturnal evolution
  - ➢ Converge mobile assets on convective region
  - ➢ Fix mobile 7-radar array (sit-and-spin), but follow MCS with other assets





Parker’s research interests

- ❑ Specific aim: Understand lower tropospheric outflow processes associated with nocturnal MCSs
  - ➢ Mechanisms for MCS maintenance (cold pools vs. waves/bores)
  - ➢ Influence of stability in the NBL
  - ➢ Influence of stability above the NBL
  - ➢ Influence of vertical wind shear in the outflow layer
  - ➢ Influence of the prior evolution of the MCS (developing vs. mature, possible history as surface-based convection)



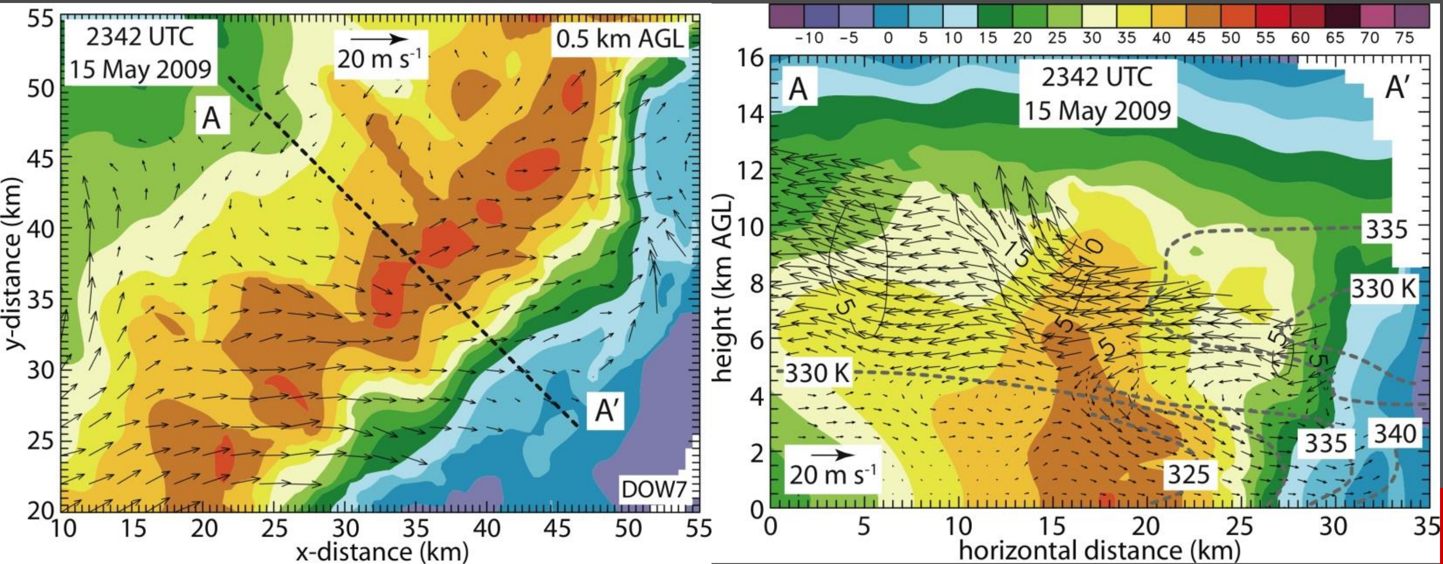
Plan view (a) and cross-sections (b-d) of a simulated “nocturnal” MCS.

Left figure: cold pool-driven (earlier)
Right figure: bore-driven (later)

from Parker (2008)

Parker’s proposed research methods

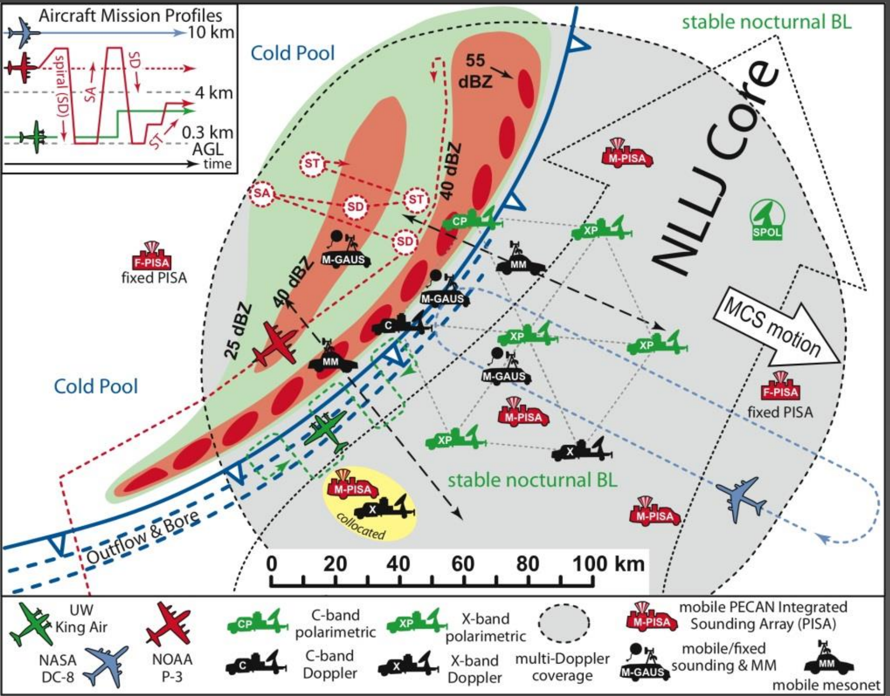
- Analysis of PECAN observations
  - Pre-MCS environment
  - MCS outflow depth, structure, and vertical parcel displacements
  - Internal MCS flow fields
- Process study simulations based upon PECAN observations
  - Initial conditions from PECAN cases
  - Sensitivity to evolving stability and wind profiles over time
  - Sensitivity to timing of initiation (relative to stabilization)



Plan view and cross-section of a VORTEX2 MCS: Radar analysis courtesy C. Ziegler, thermodynamic analysis adapted from Bryan and Parker (2010)

Parker’s data collection priorities

- ☐ Most important platforms
  - ➢ Soundings: far-field†, ahead of and behind convective regions
  - ➢ Surface obs: far-field†, ahead of and behind convective regions
  - ➢ Surface radars: High-res multi-Doppler winds and reflectivity‡ (including in regions with heavy precipitation)
- ☐ Preferred sampling methods (primarily MCS missions)
  - ➢ Start measurements early and maintain MCS-following capability
  - ➢ Converge assets on the convective regions



MCS mission deployment

†: for “far-field”, including conventional NOAA obs

‡: for “MCS history”, including WSR-88Ds

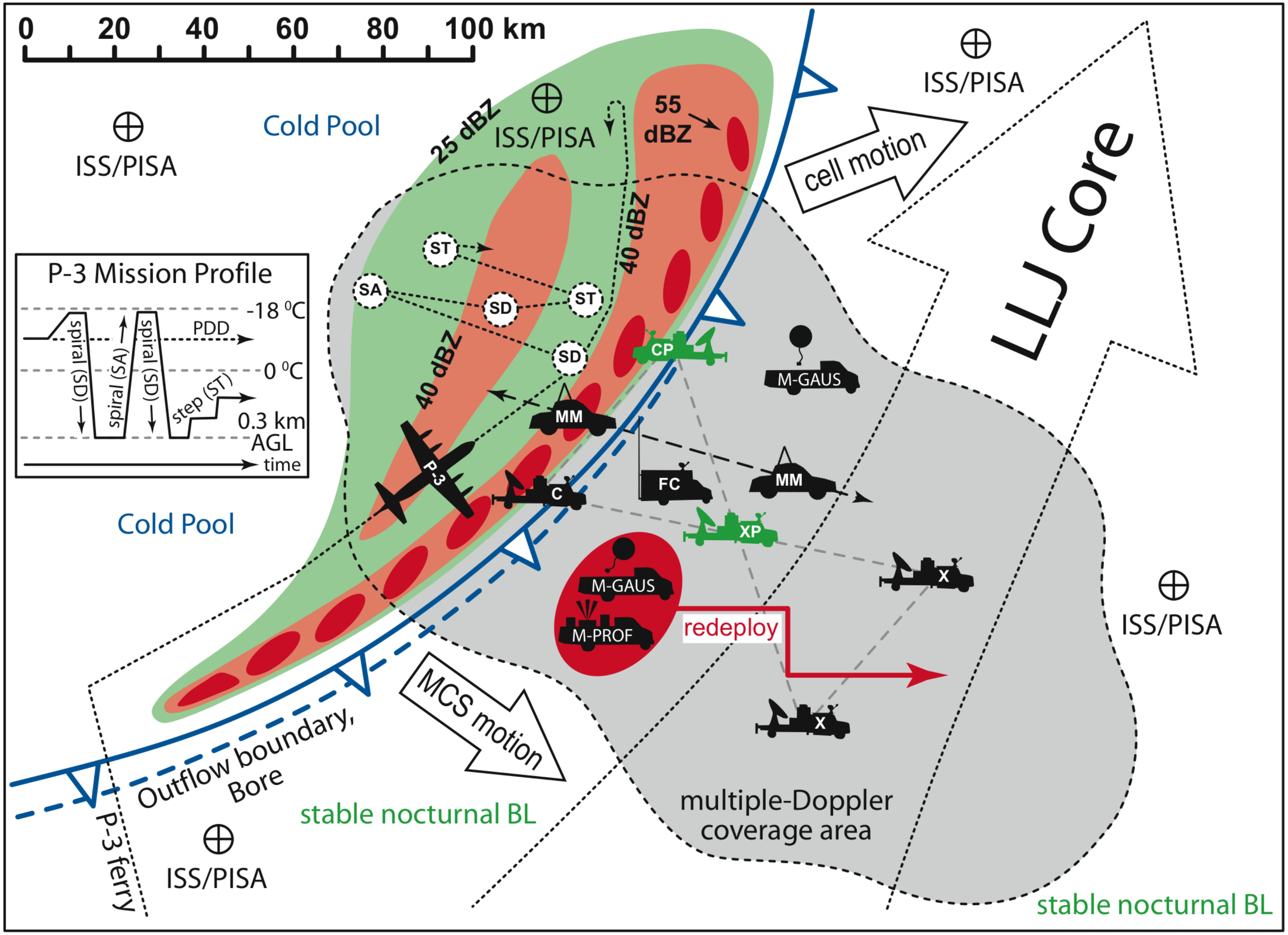
NOAA P-3 Science Objectives

D. Jorgensen
C. Ziegler
T. Schuur
N. Guy
NOAA/NSSL
Norman, OK

Science Objectives

- Overarching PECAN Goal
  - Better understanding of the initiation, prediction, and dynamics of elevated nocturnal convection
- Specific P-3 Goals
  - The role of microphysics in the transition of surface-based to elevated storm structure particularly the role of cold pools
  - Validation and development of hydrometeor classification schemes employed on the upgraded WSR-88D dual-pol radars
- Strategy: Ascent/Descent spirals in trailing stratiform region of nocturnal MCS enabling diagnostic calculations of diabatic heating/cooling rates.

Flight Strategies



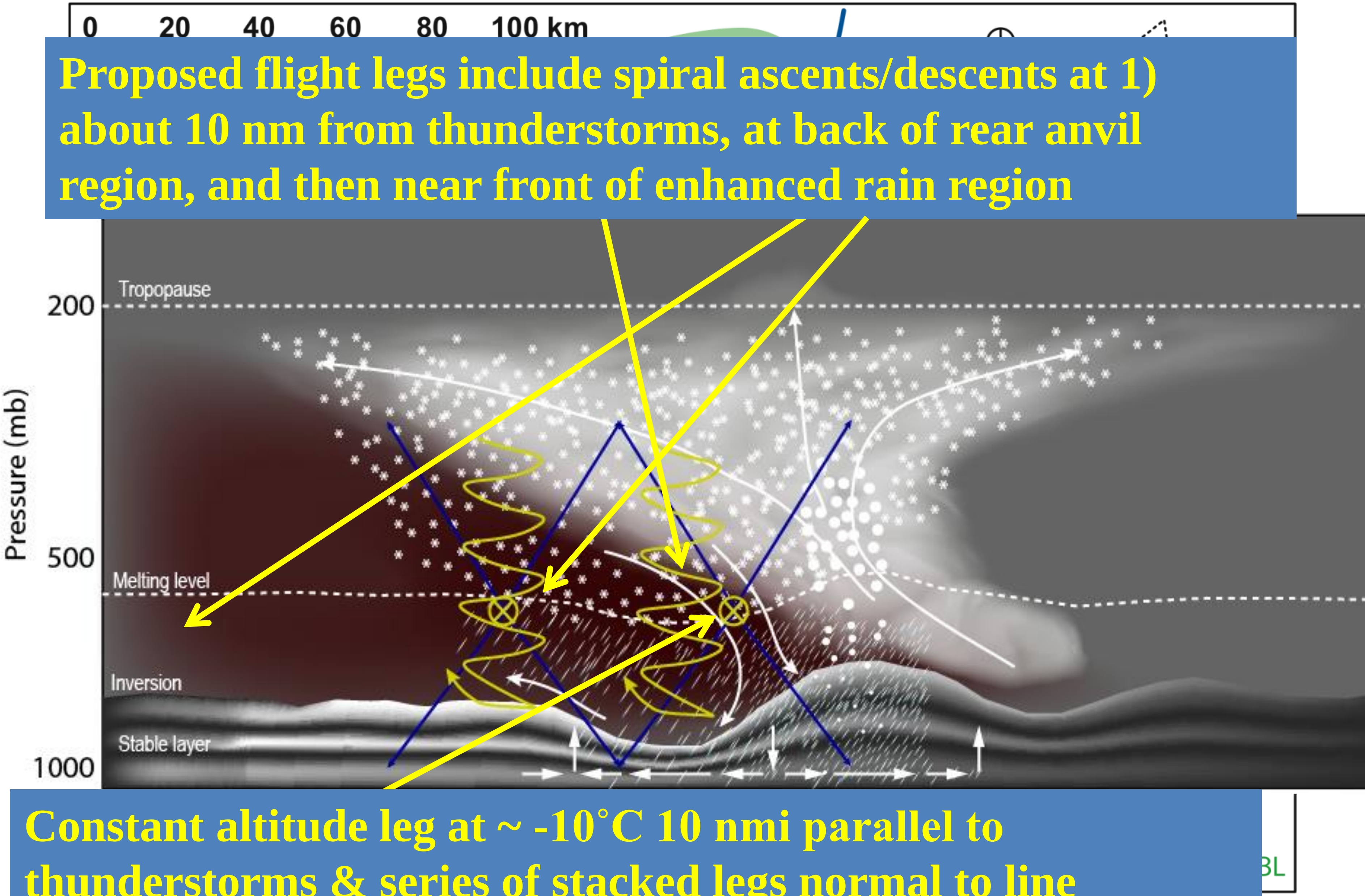
Elevated Nocturnal Convection – The role of microphysical processes

Greg McFarquhar, Bob Rauber and Brian Jewett
University of Illinois, Urbana, IL

- Overarching hypothesis: **microphysical cooling processes in developing & mature stratiform regions of MCSs force downdraft circulations that create mesoscale gravity waves & bores in the SNBL that subsequently focus, organize & maintain future convective activity**
- Tools: **P-3 μphysics, dual-Doppler radar, ground-based remote sensing, WSR-88D data & WRF simulations**

Analysis Strategy

1. Characterize μphysical & thermodynamic structure of transition zone, notch region & rear anvil region in formative & dissipative stages using μphysics, radar & profiler data
2. Quantify sublimation, evaporation, melting, diffusion, riming & aggregation in those regions, assess their contributions to latent cooling/heating, & impacts on up/downdraft circulations, bores, gravity waves and rear inflow jet
3. Determine how gravity waves give rise to lifting, and hence drive convection & subsequent generation of supercooled water & ice crystals, and therefore maintain & organize nocturnal MCSs



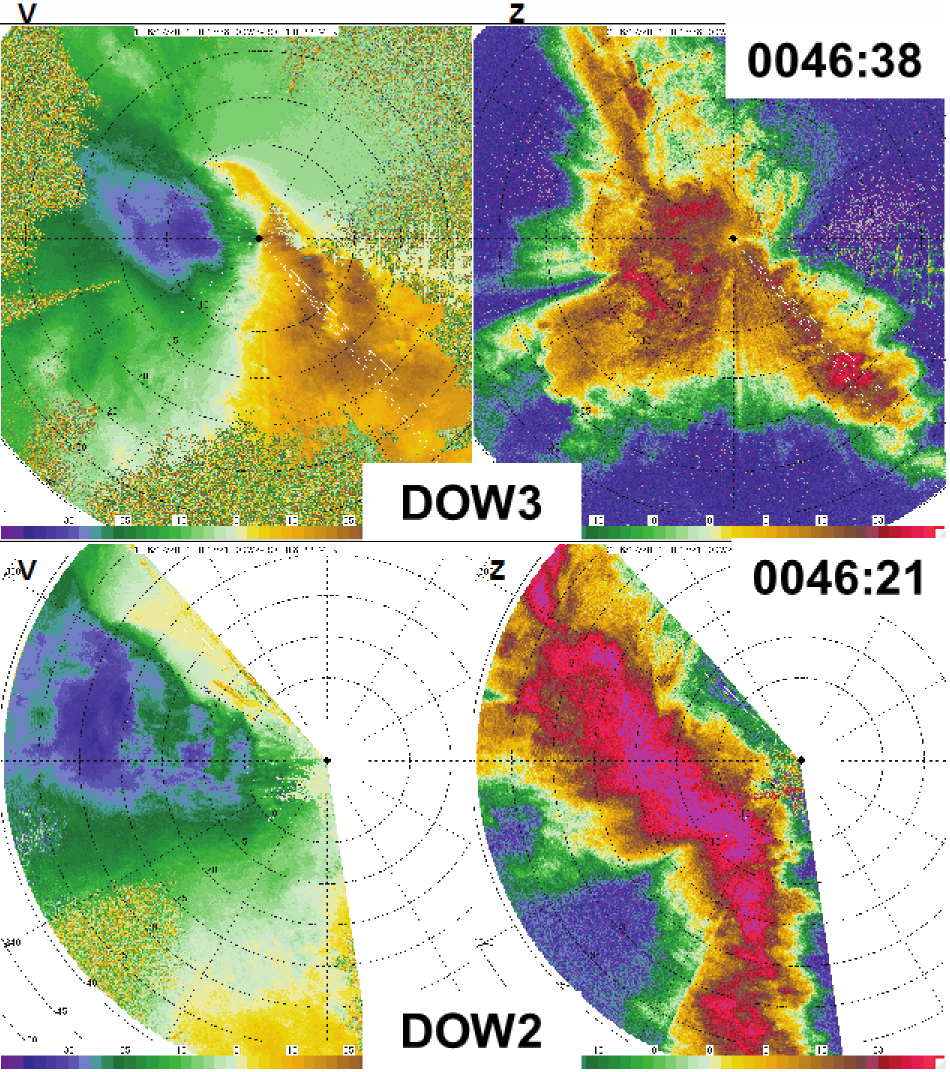
Proposed flight legs include spiral ascents/descents at 1) about 10 nm from thunderstorms, at back of rear anvil region, and then near front of enhanced rain region

Constant altitude leg at ~ -10˚C 10 nmi parallel to thunderstorms & series of stacked legs normal to line between close to leading thunderstorms & rear anvil region

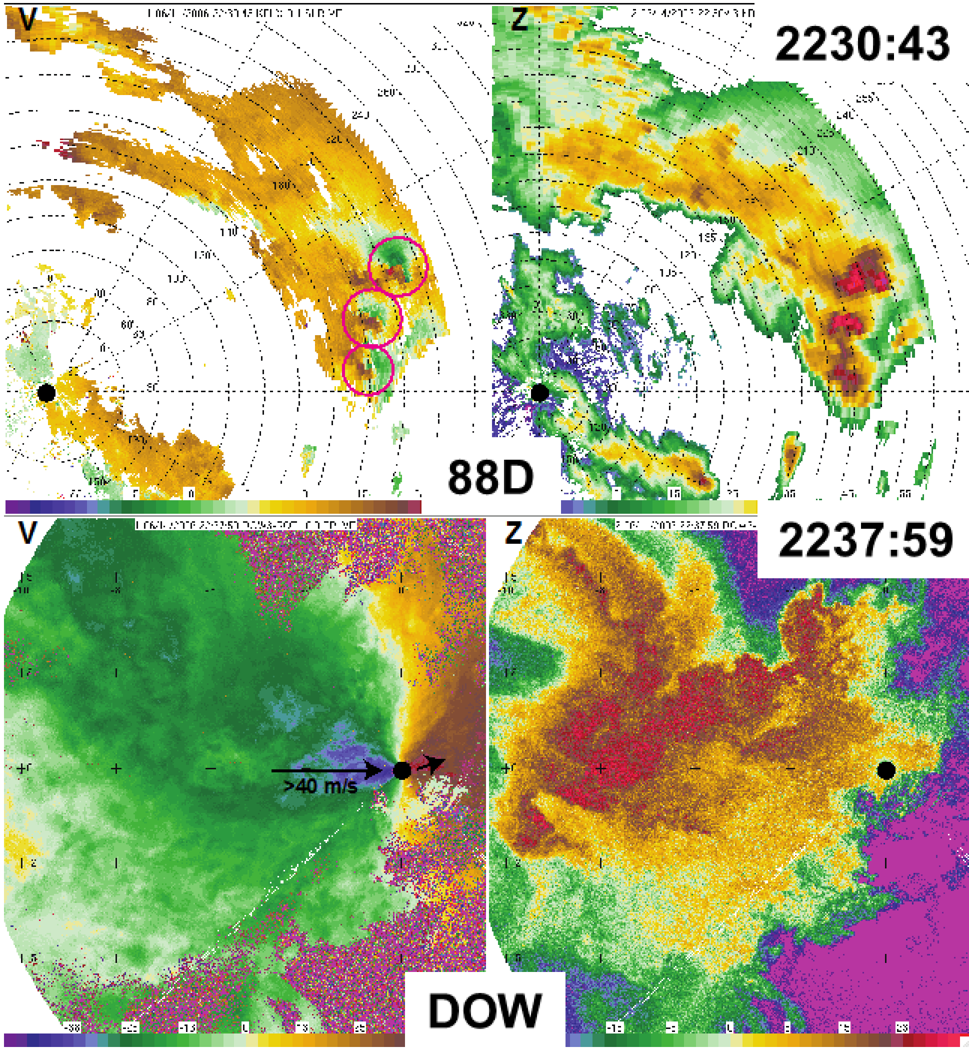
PECAN CSWR Science Objectives: MCS Dynamics

FOCUS: Dynamics, Internal Structure, and Microphysical Evolution of Severe-Wind Producing Nocturnal MCSs and Transitioning Systems

MCS in Southwest KS



Transitioning System in MT



PECAN CSWR Science Objectives: MCS Dynamics

Observational analyses will target the following questions in both MCS and transitioning systems:

- What are the specific origins of the air comprising the main updrafts of storms during the evolution of the NSBL and what are the environmental conditions during a transition from surface-based to elevated convection?

- What are the internal processes (dynamic and microphysical) and mesoscale environment characteristics of severe-wind-producing MCS events?

- How are the production of storm-scale downdrafts and low-level outflow affected by the transition from surface-based to elevated convection?

- What environmental factors (in the NSBL, above, such as low θ_E regions, and/or environmental wind shear) and storm-scale processes differentiate whether or not severe winds will occur during the mature or transition stage?

- What is the role of mesovortices in enhancing severe winds at the surface?

- What dictates when an MCS will stop producing severe winds?

- What makes a transitioning or mature system dissipate as opposed to continuing through the night as a severe wind MCS?

PECAN CSWR Science Objectives: MCS Dynamics

In order to test when and how nocturnal convection produces severe surface winds, observational data will be used to:

- Categorize the mesoscale environment in which a storm forms and at critical phases during the MCS's lifetime. This includes, but is not limited to, vertical wind shear, vertical stability, and depth and height of the NSBL.

- Categorize the MCS as surface-based, elevated, or both at critical phases during the MCS's lifetime

- Identify MCS morphology (e.g., linear versus cellular) at critical phases during the MCS's lifetime, particularly during an upscale growth period

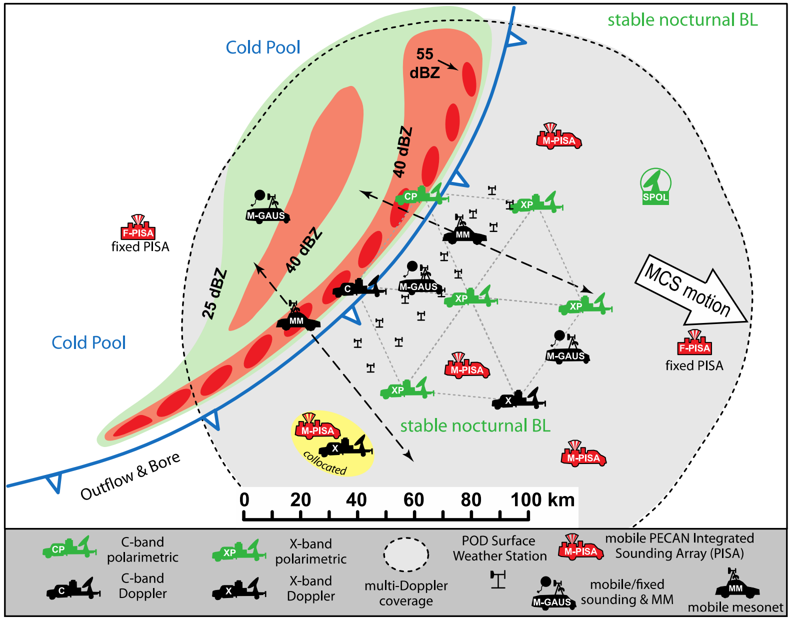
- Identify MCS propagation and sustenance mechanisms (e.g., cold pool, bore) at critical phases during the MCS's lifetime

- Identify locations of severe winds and relate these to the evolution of the three-dimensional MCS kinematic and thermodynamic structure through fine-scale multi-Doppler and dual-polarization variables (i.e., hydrometeor type and implied microphysical properties), and, if present, quantify the strength of the cold pool.

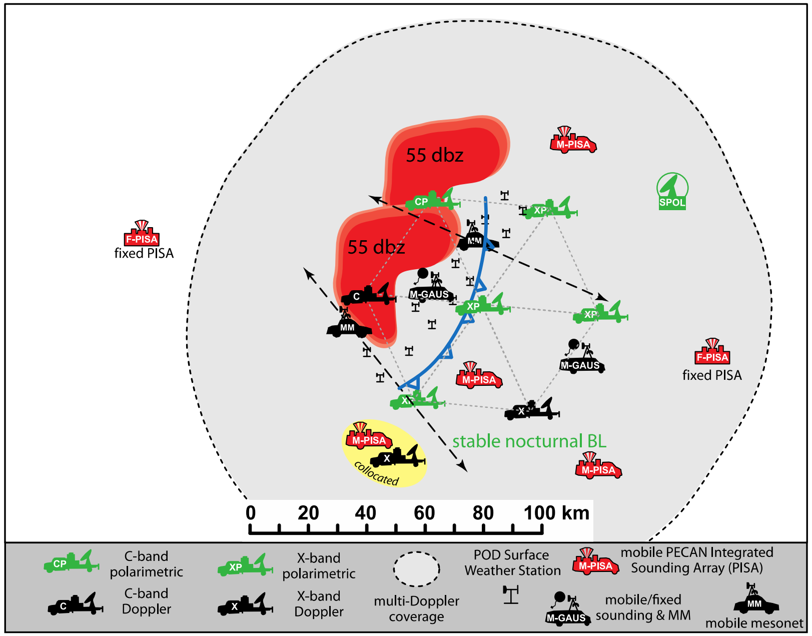
- Calculate trajectories and identify parcel origins

PECAN CSWR Science Objectives: MCS Dynamics

Instrument	Anticipated data
Mobile radar network	3-dimensional wind mapping, storm and cold-pool microphysics
S-Pol and WSR-88D network	Storm-scale single Doppler data (occasional multiple-Doppler with mobile radars), microphysics (verification)
Radiosondes	Vertical thermodynamic and wind structure of ambient environment
MIPS	PBL top, inversion, BL stability, shear profile, LLJ
PISAs, surface weather stations, mobile mesonets, disdrometers	Surface thermodynamic environment, Surface boundaries Particle identification



Location of surface weather stations and mesonets relative to the multi-Doppler radar array.



Example deployment of PECAN assets on a transitioning system.

Scientific Interests Related to PECAN

Stan Trier (NCAR/MMM)

Collaborators: Tammy Weckwerth, Jim Wilson, Rita Roberts, Jenny Sun

- **Quantification of Mechanisms resulting in CI and MCS Sustenance**

Fine-scale flow inhomogenenties, e.g., bores, gravity waves, outflow boundaries

* Mesoscale thermodynamic destabilization

-Influences whether inhomogeneties can trigger

-Determines regionalization of organized convection (e.g., will MCSs be in SE Kan, NW Texas, etc.?)

- **Internal and External Factors Resulting in Successive MCS Activity**

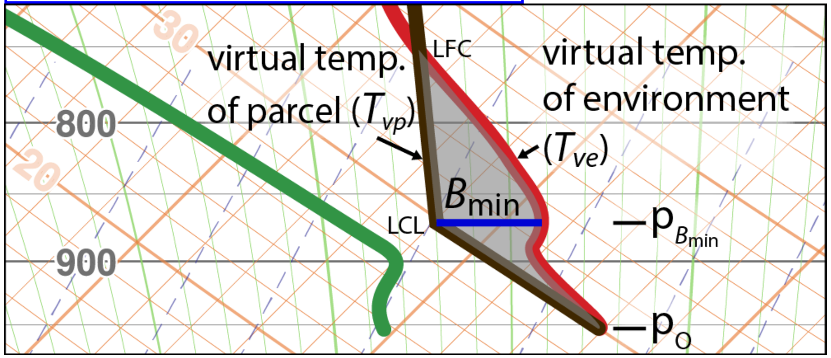
Series of Convective Complexes (Fritsch et al. 1986, *J. Climate Appl. Meteor.*)

Multiday Latitudinal Precipitation Corridors (Tuttle and Davis 2006, *Mon. Wea. Rev.*)

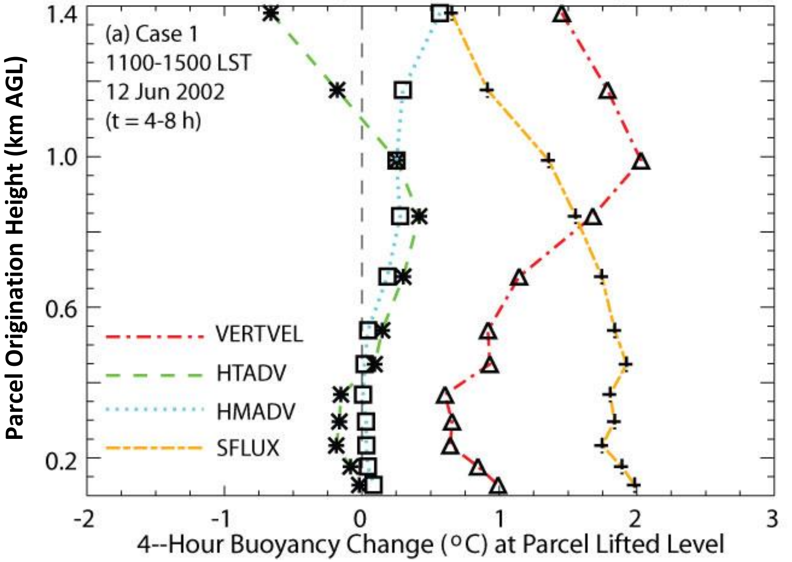
PECAN Planning Meeting, Boulder, CO, 12-14 May 2014

Diagnostic to Compute Trends in Thermodynamic Destabilization and Processes Responsible

Bmin (parcel minimum buoyancy)



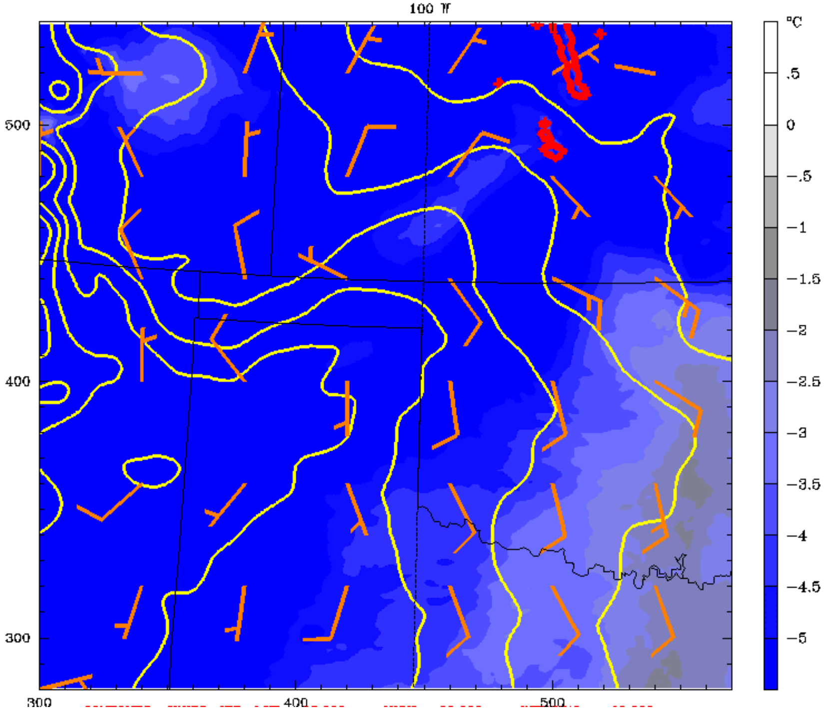
Net Effect of Different Physical Processes on Buoyancy Change

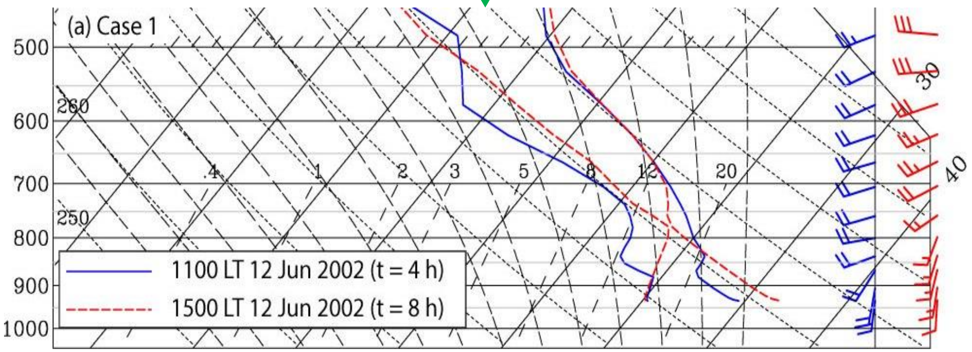


WRF Simulation (13 UTC 12 Jun to 00 UTC 13 Jun 2002)

Fcst: 1.00 h Valid: 1300 UTC Wed 12 Jun 02 (0700 MDT Wed 12 Jun 02)
minimum buoyancy (Tv,lift−Tv,env) at k−index = 42 sm= 2

11-hour Loop of Bmin, surface θ, winds and dbZ >35 (red)





Related Papers:

Trier et al. 2014a, *Mon. Wea. Rev.*, 142, 945-966. (MCS Initiation Environments)
Trier et al. 2014b, *Mon. Wea. Rev.*, 142, 967-990. (Mature MCS Environments)

Research Plans for PECAN

- Studies of PECAN elevated convection cases occurring in different Environments
  (collaborating with T. Weckwerth, J. Wilson, R. Roberts, J. Sun)
  - Model-based Bmin budgets diagnosing mesoscale thermodynamic destabilization for PECAN cases
- Examine utility of Bmin trends in nowcasting (CI)
  - Continuous field that doesn't require there being CAPE
  - Representativeness issues (use of only two sounding levels more subject to noise than using CIN)
  - Is this a significant issue for observed high-resolution vertical resolution soundings?
- Exploration of different methods for assessing convective inhibition
  - Traditional vertical averaging of parcels vs. vertical distributions of point parcels?
  - How best to utilize vertical distributions of Bmin/CIN values for CI forecasting?

PECAN Data Needs

- Soundings (90-min frequency required for trends of stability parameters)
- Surface Mesonet(s) (monitoring of lower-tropospheric flow structure)
- Wind Profilers (monitoring of free-tropospheric flow features)

PECAN Science and Education Plan

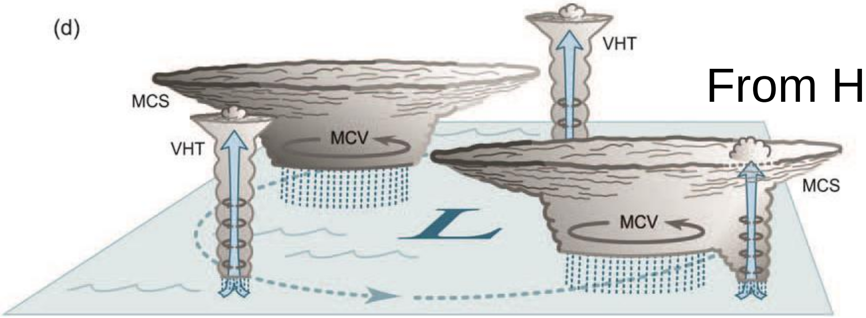
Michael M. Bell
University of Hawaii

- PECAN participation funded under NSF CAREER grant titled “*Impacts of Convective and Stratiform Processes on Tropical Cyclone Intensity Change*”
  - Integrated radar education component
  - Role of precipitation processes in convective organization and dynamic feedbacks

Education Plan: Radar and Aircraft Observations in PECAN

- PECAN is an excellent opportunity for graduate students to get hands-on experience collecting radar data in the field
- Funding for 2 students (one ground-based with DOW, one airborne with NOAA P-3) to participate in PECAN
  - 6-week support already arranged for DOW
  - 2 weeks with NOAA-P3 funded, longer time is possible for other student with more funding

Science Plan: Convective and Stratiform Contributions to MCS Longevity

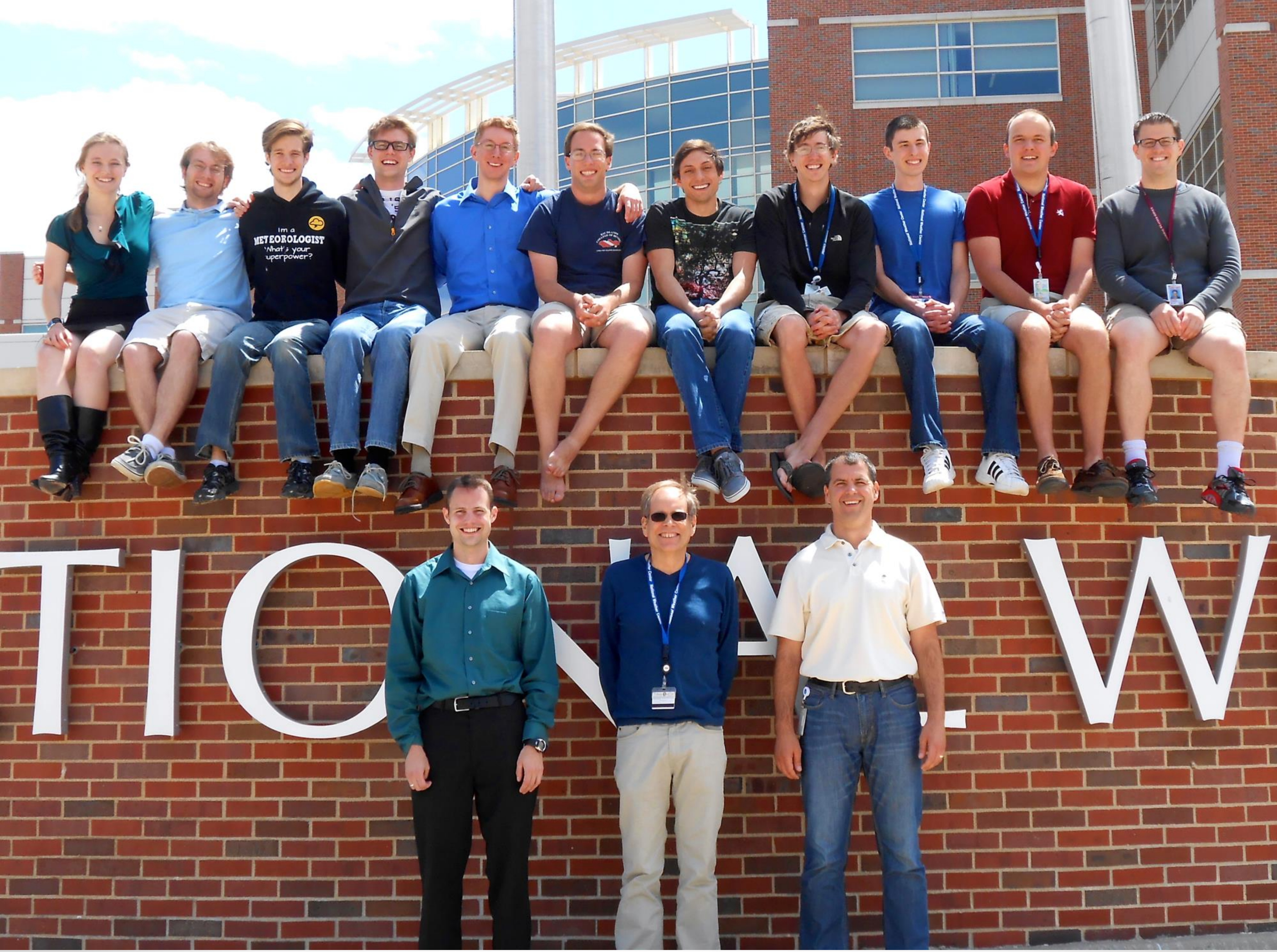


From Houze et al. 2009

- Convection type, longevity, and interactions with the boundary layer are important factors in tropical cyclone (TC) intensity change.
  - RKW theory is applicable to certain types of TC rainbands (Tang et al., in press)
  - Nocturnal MCSs may play a critical role in TC genesis (Bell and Montgomery, in prep)
  - TC simulated intensity is very sensitive to uncertainties in microphysics parameterizations
- **Compare mesoscale divergence profiles, precipitation structures, and microphysical data in nocturnal, continental MCSs with tropical, oceanic MCSs**
- **Use SAMURAI (Bell et al. 2012) to integrate multiple observing systems**
  - **Quick-look analyses in the field depending on real-time data availability**

Nocturnal bores, disturbances on the SBL

Dave Parsons et al., OU	**Bore dynamics, nocturnal MCSs, and downstream influences**
Kevin Knupp, UAH	**Nocturnal disturbances, modes of propagation of QLCS/MCS, and evolution of boundaries during the AET**
Bart Geerts and Zhien Wang, U. Wyoming	**Airborne observations of bores & CI**


Im a
METEOROLOGIST
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W

PECAN RESEARCH

- **Investigate the mechanisms proposed for explaining the evolution of nocturnal convection** over the Southern Great Plains with a focus on evaluating the findings of Haghi and Parsons (TBS – summer 2014) and Parsons et al. (TBS – summer 2014)

- **Explore the dynamics of observed and simulated bore-like features** to explain: i) Differences between the observations and conceptual models from 2-D dynamics in idealized environments (e.g., 3-D nature, not a stable layer feature, tilting with height of phase fronts etc); ii) Bridge the gap between stable wave and convective theory – same papers as above

- **Continue to investigate the downstream implications of the poor representation of nocturnal convection in global models** (e.g., build on ECMWF work of Lillo and Parsons – TBS June 2014)

Comments on Observational Needs

- **We will bring RAX-POL, T-WOLF, and the FM-CW to the fiel**d
- **Soundings and ISS are critical** especially the new 449 MHz Spaced Antenna system and **a flexible launch on demand** sounding array (1-2 hr frequency, sondes launched ~30 mins ahead of MCS and bore features)
- **Downside of current PECAN design** : i) a lack of a dense surface array (e.g., radar alone is an unreliable tool for determining bores from gust fronts); ii) sparse data in the western domain (SW hole); iii) A lack of sufficient acknowledgement of the linkages between themes in the types of IOPs

UAH research activities during PECAN

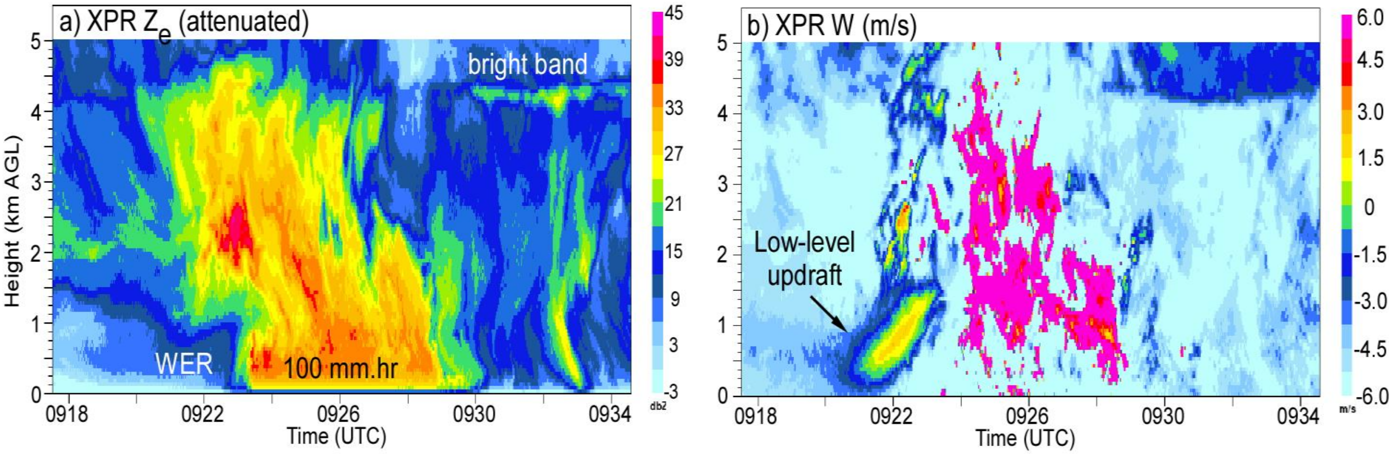
Kevin Knupp

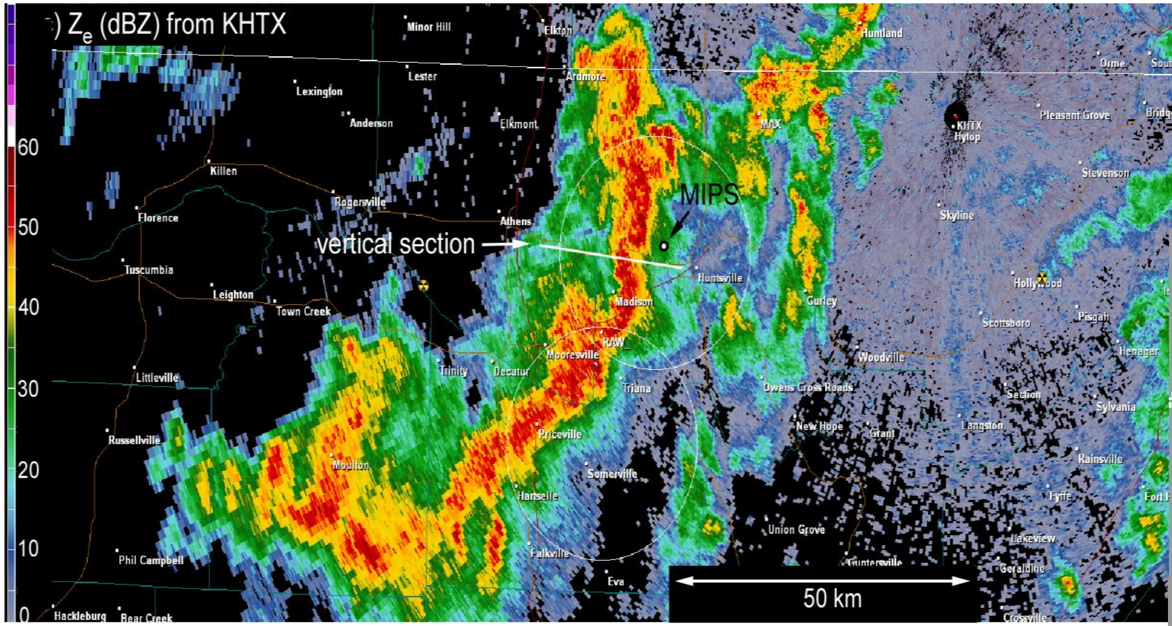
Key research interests

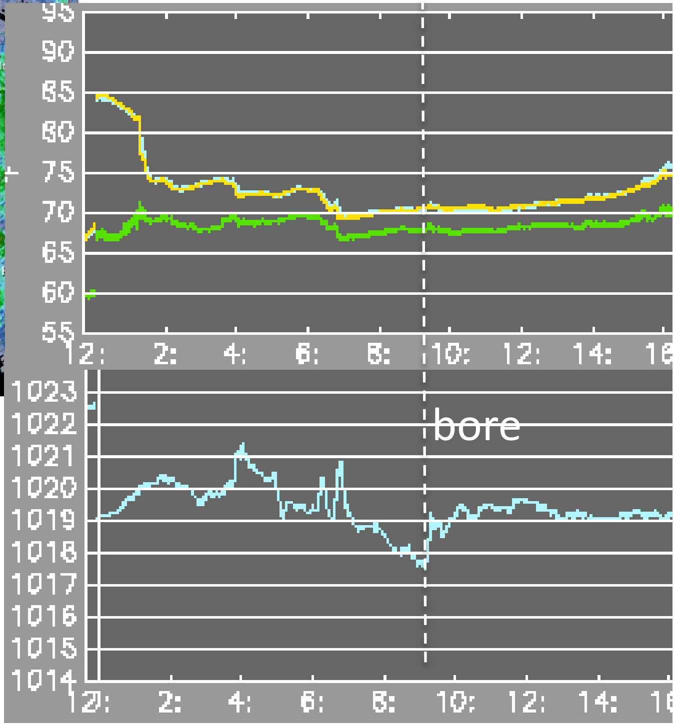
Nocturnal disturbances
Modes of propagation of QLCS/MCS
Evolution of boundaries during the AET

Bore propagation of a QLCS on 31 July 2013

- Smooth low-level updraft co-located with a WER
- Pressure jump, no change in T or T_d
- This bore event was preceded by deep convection of various modes



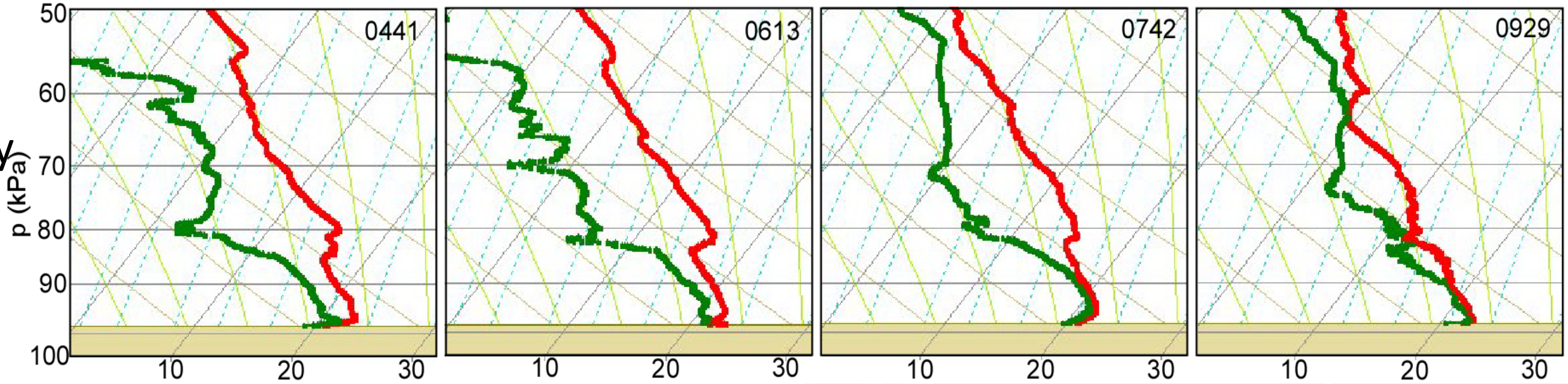




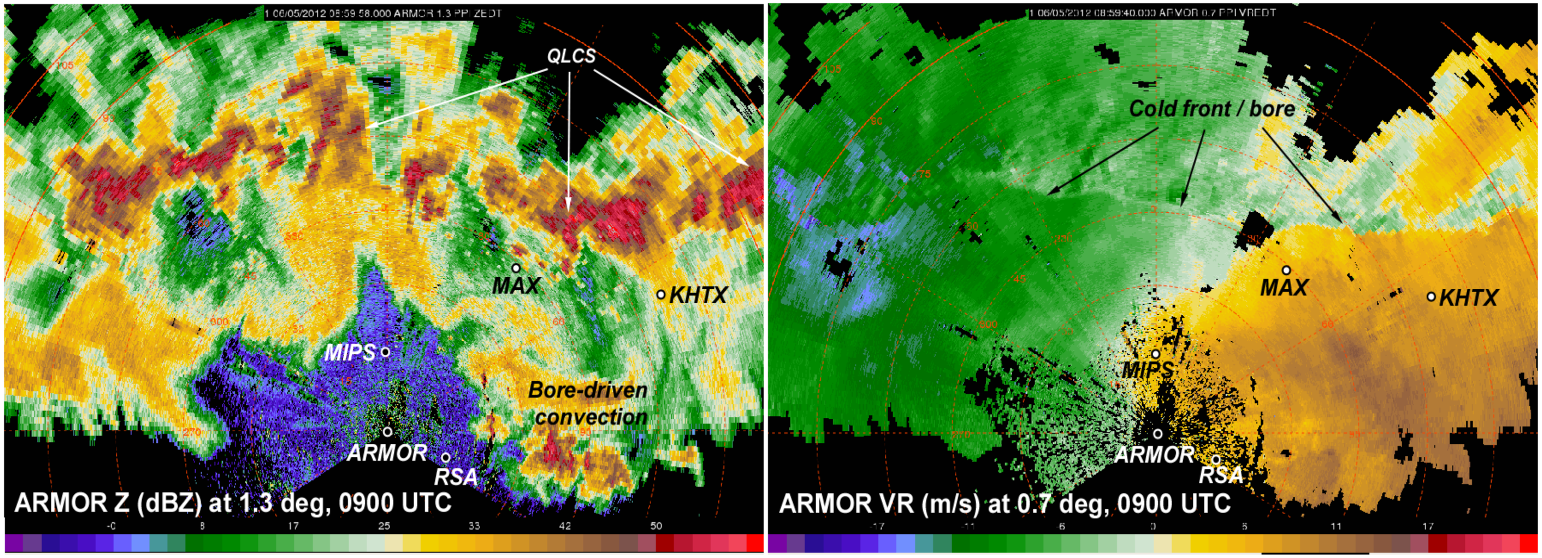
Our observations of nocturnal QLCS's suggests that bore-like propagation is common

Destabilization in advance of QLCS on 6/2/2012

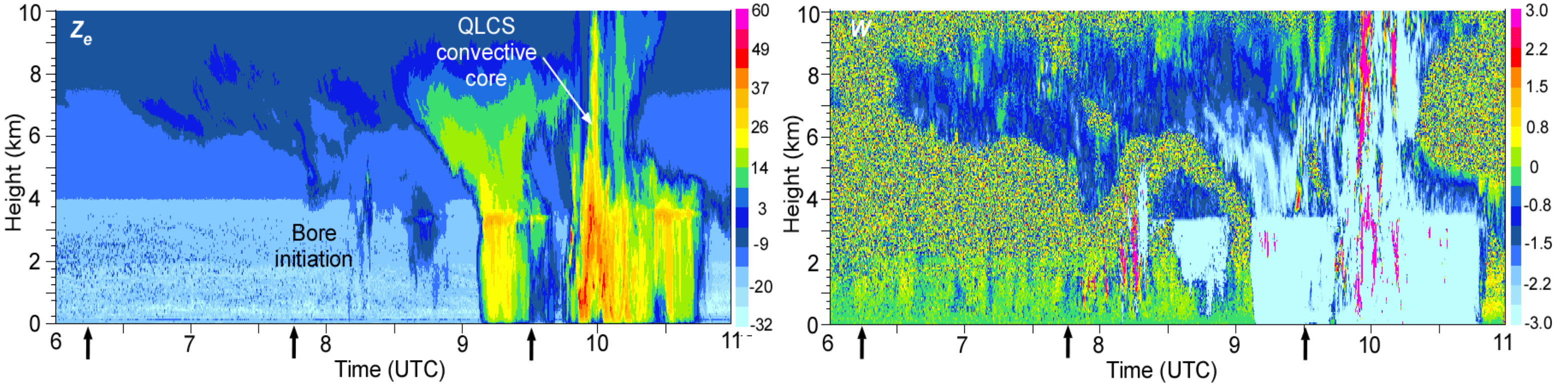
Destabilization was produced by advection of water vapor and bore activity



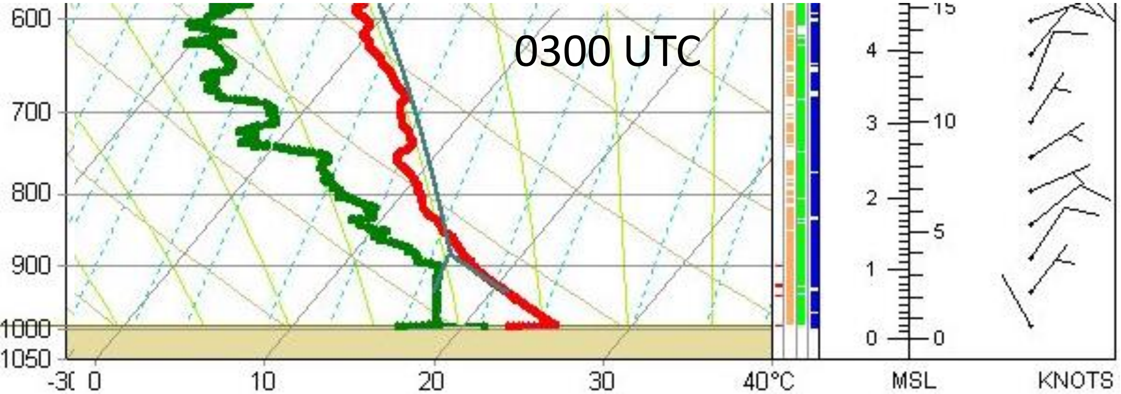
Generation of bores in advance of the main convective line. Complicated behavior.



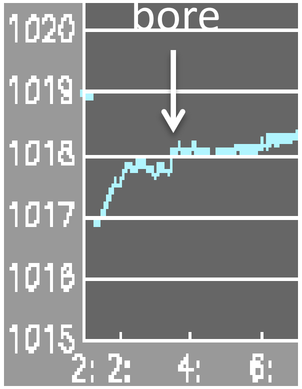
Time-height section of Z and W showing passage of bore and convective line. Arrows denote sounding times.



NB: disturbances: A shallow, weak, persistent bore



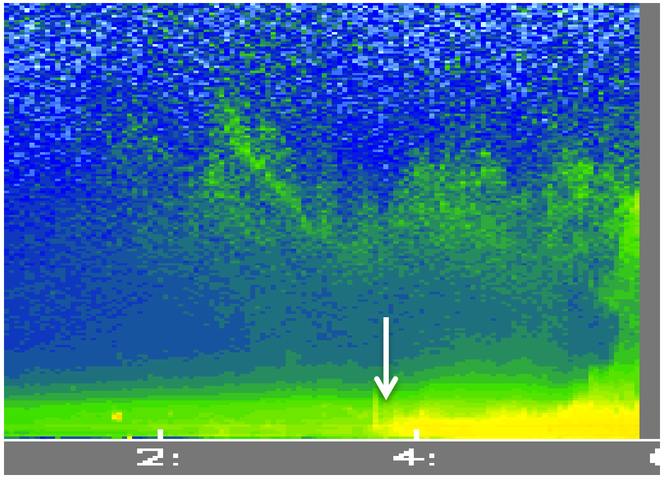
Shallow surface-based inversion, weak flow and shear



Pressure increase ~0.3 mb

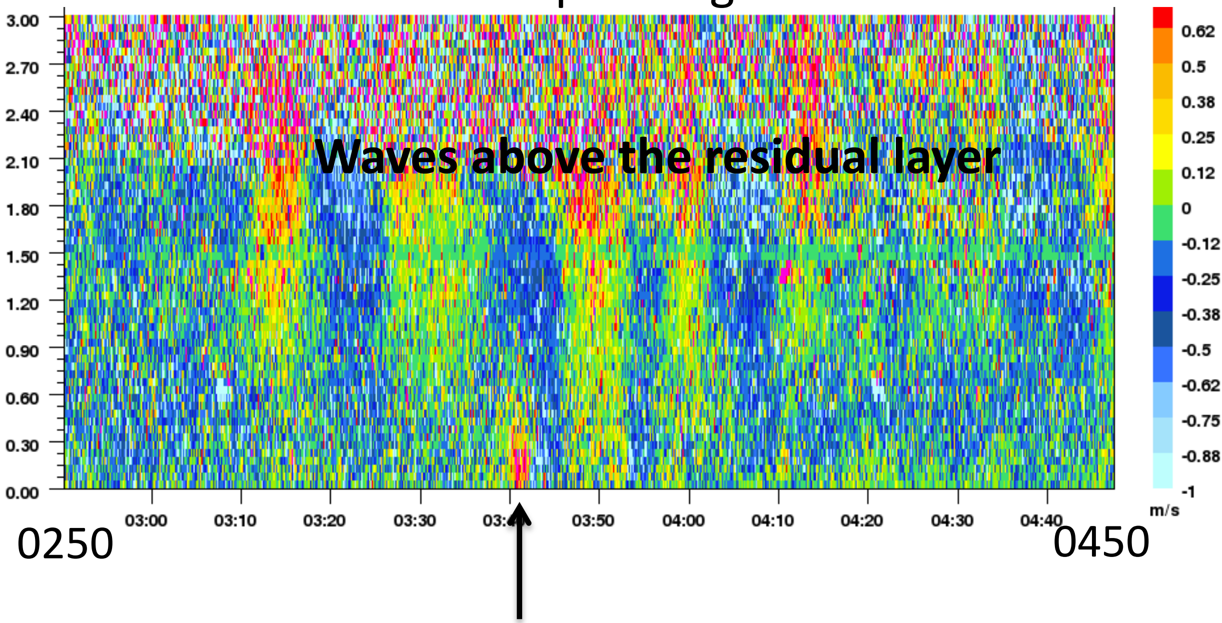
Increase in wind speed from near calm to 2.5 m/s

CL51 ceilometer



Increase in aerosol backscatter at low levels

X-band profiling radar



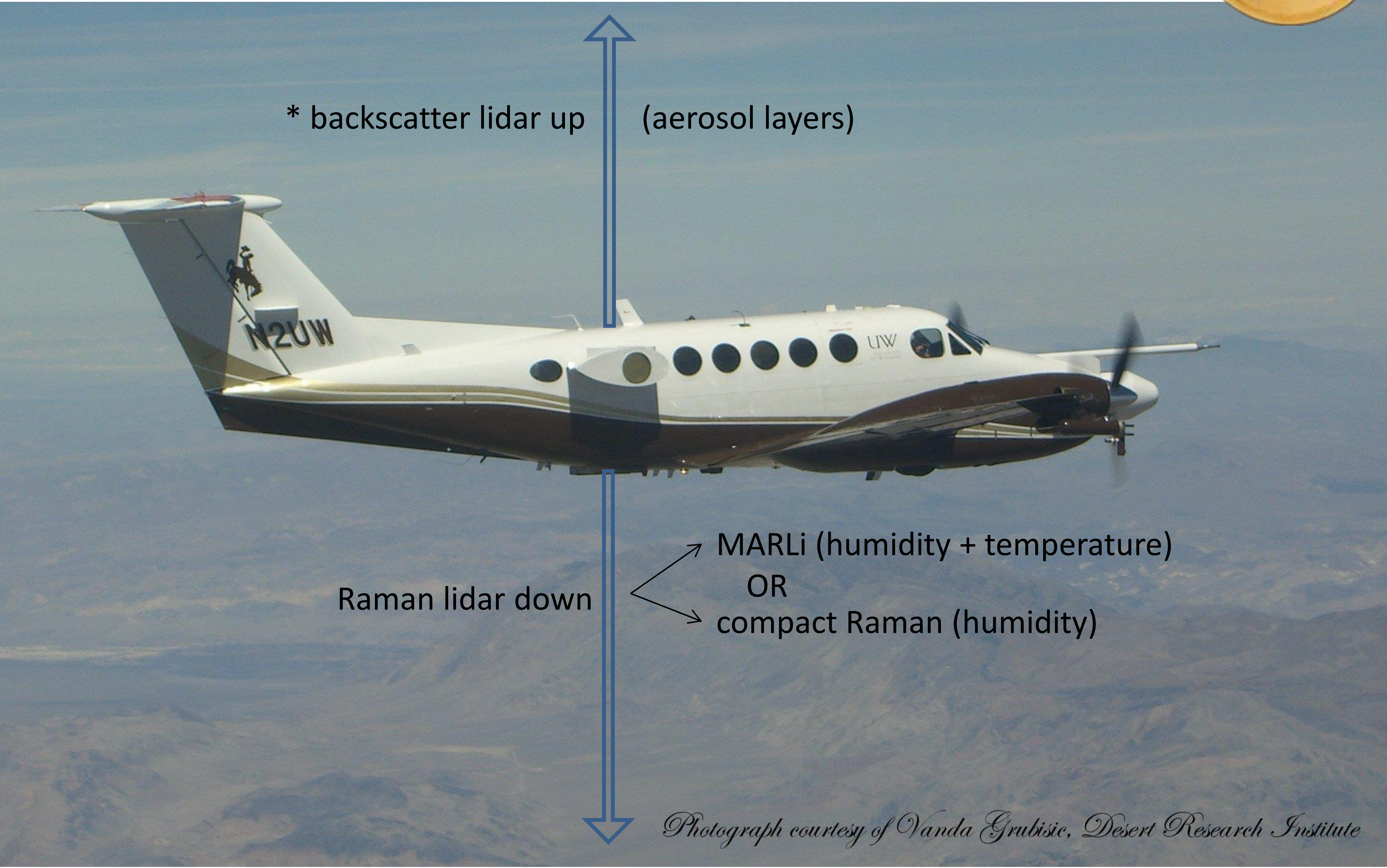
Shallow bore updraft (<1 m/s)

CBZ enhancement during the AET

Reduced $\langle w'\theta' \rangle$ and $\langle u'w' \rangle$ ➔ increased $\nabla \bullet V_h$ ➔ CI and/or bore generation

AET2: The decay of large eddy turbulence during the AET reduces the cellular structure of CBZs (e.g., misocyclones), rendering the CBZ more 2-D, slabular, and efficient in lifting air to the LCL/LFC.
AET3: An increase in convergence within CBZs during the AET is most prominent in persistent, slowly moving CBZs such as mature outflow boundaries, cold fronts, warm fronts, and drylines.

Bart Geerts & Zhien Wang:
Airborne measurements of wave disturbances in the SBL



* backscatter lidar up (aerosol layers)

Raman lidar down

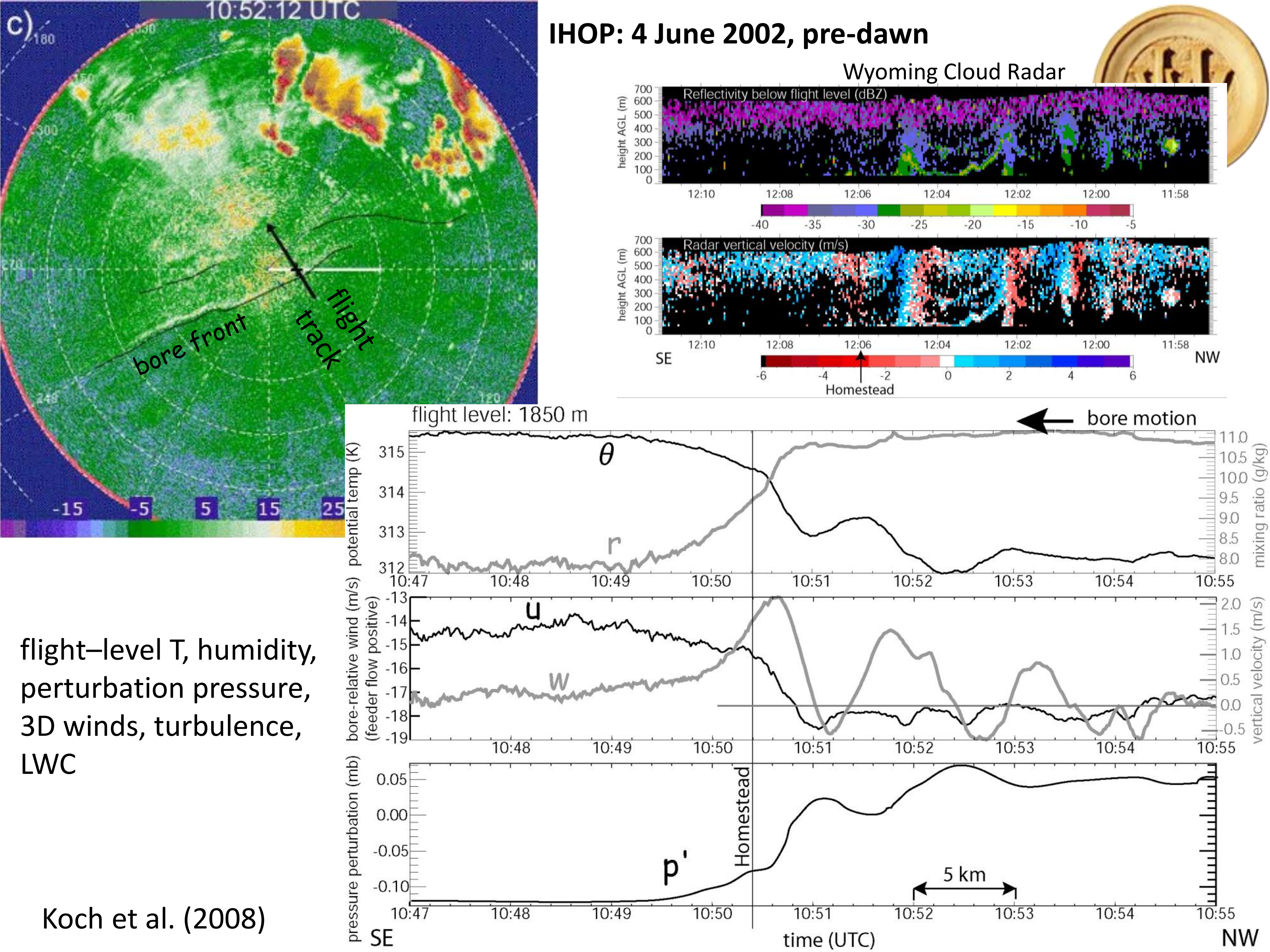
MARLi (humidity + temperature)

OR

compact Raman (humidity)

Photograph courtesy of Vanda Grubisic, Desert Research Institute

IHOP: 4 June 2002, pre-dawn



flight–level T, humidity, perturbation pressure, 3D winds, turbulence, LWC

Koch et al. (2008)

objectives

- to describe the fine-scale 2D (vertical plane) water vapor and temperature distribution of the SBL and of SBL wave disturbances in the vicinity of nocturnal MCSs and in the advent of CI, mainly using airborne lidar data.

- to document the structure, properties and evolution of bores/solitons in unprecedented detail, to gain insight in the behavior of these wave phenomena in the context of the observed ambient stability and shear profiles, and to examine their role in CI.

Nocturnal convection initiation

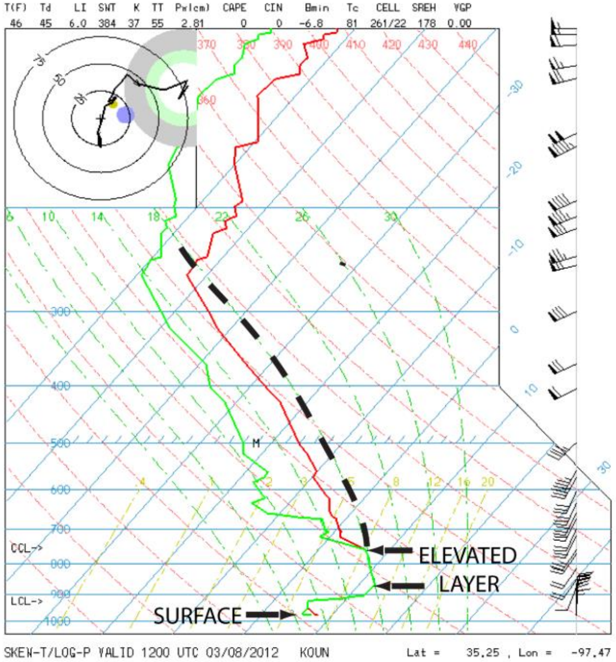
Howie Bluestein, OU	**Initiation and organization of elevated convection**
Dylan Reif, OU	**Climatology of nocturnal elevated convection initiation**
Tammy Weckwerth et al., NCAR	**Elevated convection initiation and evolution**

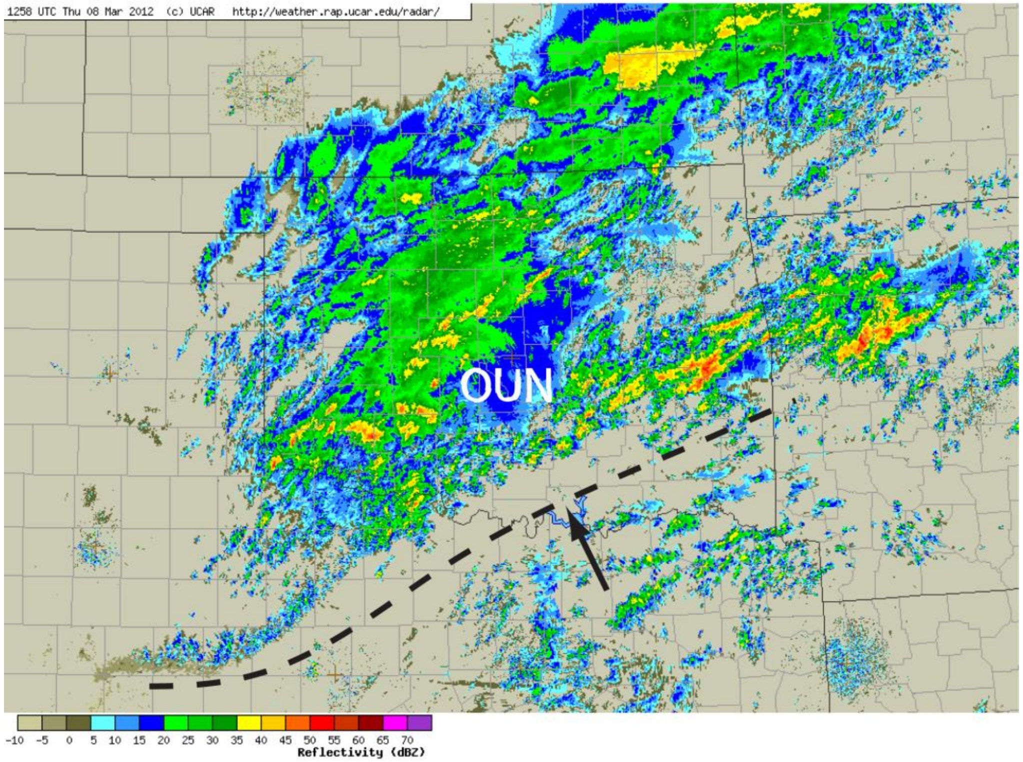
INITIATION AND ORGANIZATION OF ELEVATED CONVECTION

Howie “Cb” Bluestein
School of Meteorology
University of Oklahoma
Norman

- CLIMATOLOGY STUDIES, WITH DYLAN REIF

- MY OWN INTERESTS ARE ELEVATED CONVECTION *IN GENERAL*, NOT JUST NOCTURNAL CONVECTION: PECAN IS AN EXCELLENT PROJECT FOR ME BECAUSE MOST NOCTURNAL CONVECTIVE SYSTEMS ARE ELEVATED





From Bluestein (2013): *Severe Convective Storms and Tornadoes*

- WHEN/WHY DO WE GET CELLS?

  LINES?

  STRATIFORM AREAS?

- WHAT HAPPENS WHEN SFC GUST FRONT MAY NOT PLAY ANY ROLE? DOWNDRAFTS FROM ELEVATED CONVECTION SIMPLY REINFORCE THE SFC COLD POOL – NO DYNAMICS AT LEADING EDGE A LA RKW THEORY

- OR, DO WE GET ELEVATED COLD POOLS? I.E., DOES ORIGINAL COLD POOL ACT LIKE A RIGID BOUNDARY BECAUSE IT IS SO STABLE? DO ELEVATED COLD POOLS GENERATE GRAVITY WAVES?

Climatology of Elevated Convection Initiation at Night

Dylan Reif

MS Student – The University of Oklahoma

Advisor: Dr. Howard Bluestein

Objectives

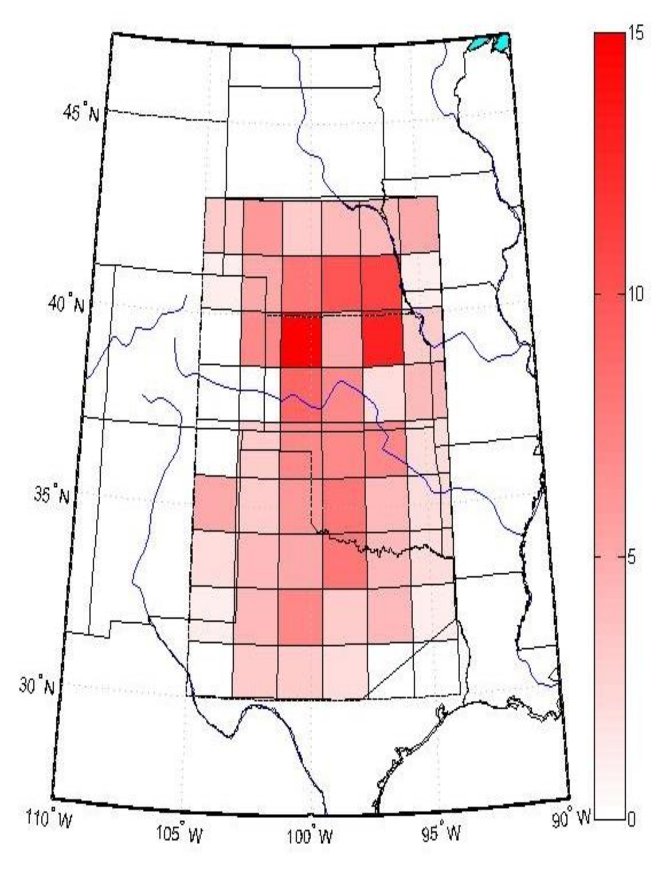
- A detailed climatology of elevated convection initiation at night over the central plains has not yet been formulated.
  - There have been a few studies that looked at elevated severe convection, or elevated convection associated with frontal surfaces (Horgan et al. (2007) and Colman (1990a), respectively), but not specifically elevated convection initiation at night.
- The purpose of this project is to determine a climatology of elevated convection initiation at night over the central plains.

Methodology

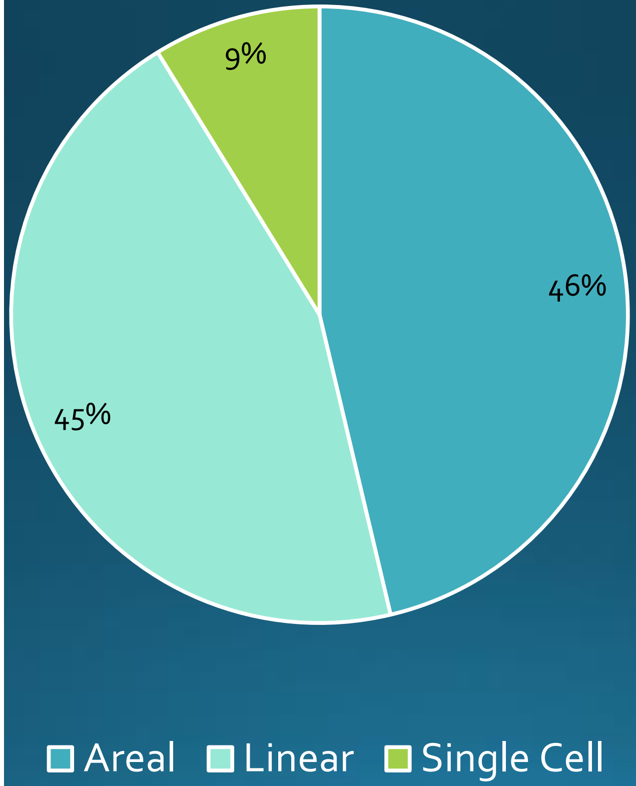
- Use WSR-88D data from the locust.mmm.ucar.edu radar composite archive to identify cases of convection
  - Dates include April – July between 1996 and 2013 (I'll likely add 2014 too).
- Document any event that I see as definite or marginal
- Classify these events as specifically as I can
  - Formation time, Formation location, type of storm, orientation of line, storm motion, etc…
- Examine surface data, upper air data, wind profiler data, proximity soundings, etc… to determine if the event is elevated or not.
- Create a climatology based on these events.
- Eventually, use PECAN data and see how well the climatology conforms to what occurs during the field experiment.

Results so far…

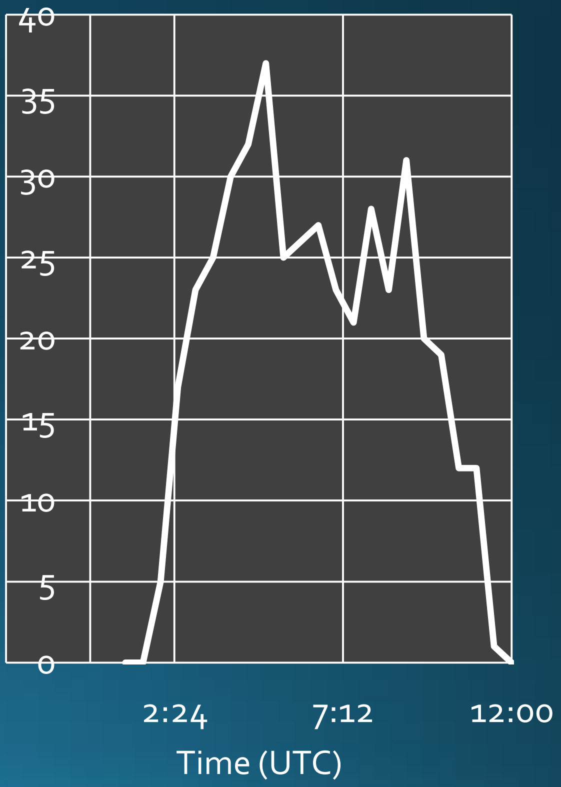
Definite Formation Location



Definite



Definite Formation Time



Elevated Convection initiation and Evolution

Tammy Weckwerth, Jim Wilson and Rita Roberts

Primary objective: Find the triggers leading to ECI and MCS maintenance and determine the predictability of these events

Hypothesis: The coexistence of elevated convergence (0.5-5 km MSL) and thermodynamic instability with triggering mechanisms, such as gravity waves, is detectable and these aspects influence the timing and location of ECI events, as well as MCS evolution.

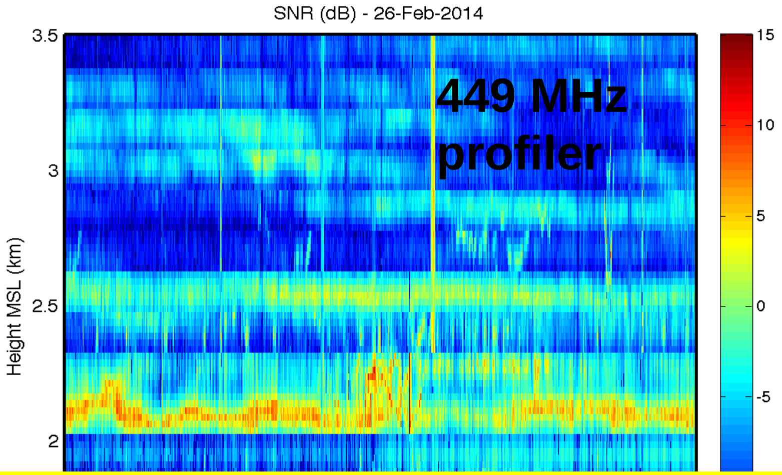
26 Feb 2014 LATTE

0.5° SUR

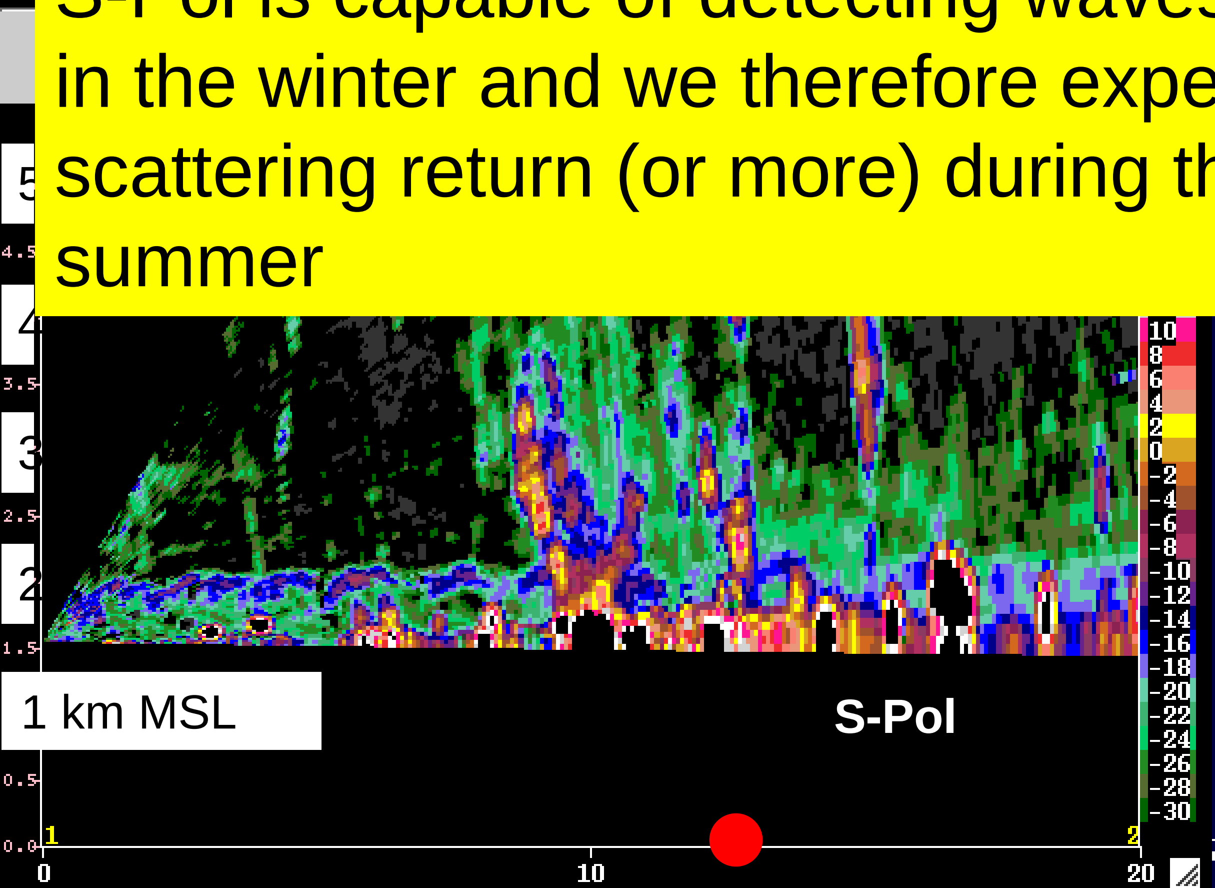
CO in winter: cold and clear

No insects

No clouds



S-Pol is capable of detecting waves by Bragg scattering in the winter and we therefore expect the same Bragg scattering return (or more) during the PECAN nighttime summer



scattering layer at top of BL; also Bragg layers at 2.5 km and 2.8 km, similar to 449 MHz profiler

Required Instruments

- S-Pol: high-resolution RHIs to monitor for waves and bores and SURs to watch for ECI
- Wind profilers to continuously monitor for waves, desired to have 449 MHz profiler within S-Pol range
- Soundings with 90-min frequency to monitor stability and spatial variability in stability
- Water vapor DIAL at 449 MHz profiler site to monitor trends in moisture
- UWKA to map out mid-level (700 mb) confluence field
- NASA DC-8 with LASE to map out moisture field and wind confluence field from in-situ observations
- Surface station networks to monitor for waves
- VDRAS for wind field analyses
- WRF for case study simulations

Data assimilation, NWP, prediction

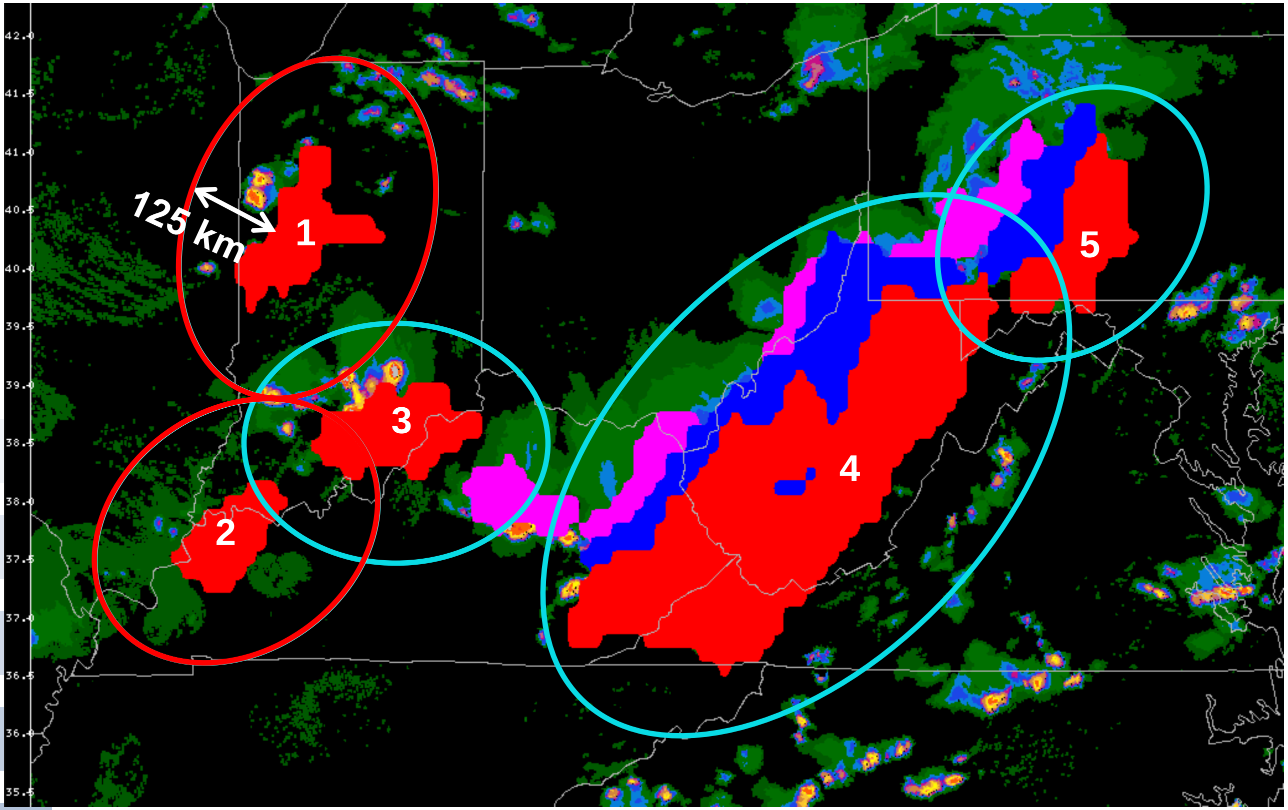
James Pinto, NCAR	**Operational NWP Assessment of MCSs**
Xuguang Wang et al., OU	**Improving the Understanding and Prediction of Nocturnal Convection through Advanced Data Assimilation and Ensemble Simulations for PECAN**

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Operational NWP Assessment

James Pinto
NCAR
Research Applications Laboratory

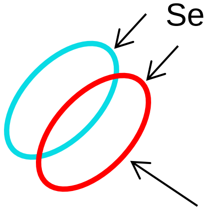
Large-scale Convective Storm (LCS) Detection Algorithm



LCS Criteria

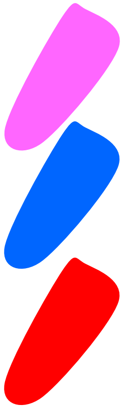
VIL > 3.5 kg m^{-2} (~40 dBZ)
Gaps < 10 km permitted
Storm Max Dimension > 100 km
Storm Lifetime >/=1 hr

LCS- I Criteria



Search radius – 125 km

initiation



T0 – 2hr

T0 – 1hr

T0

Observed Vertically Integrated Liquid (VIL) from Corridor Integrated Weather System (CIWS) - Crowe and Miller (1999)

- 5 min data; 1 km resolution; 0.0001 precision

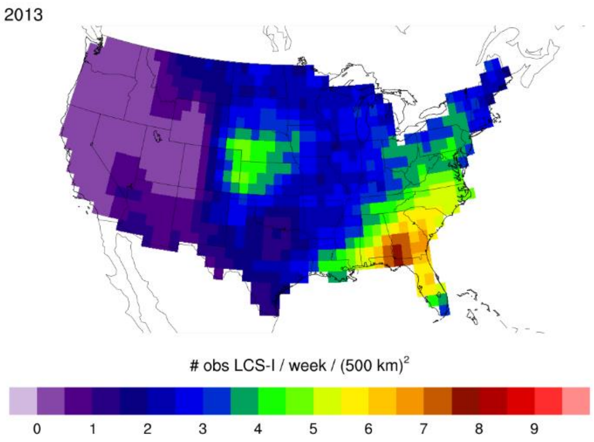
LCS Criteria (similar to Coniglio et al. 2010)

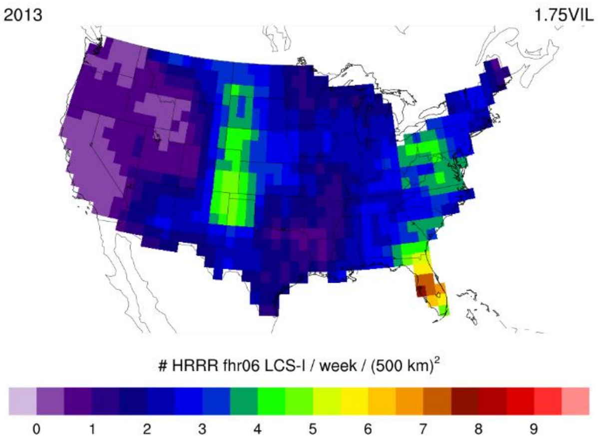
Use TITAN (Dixon and Wiener 1993) to detect LCS

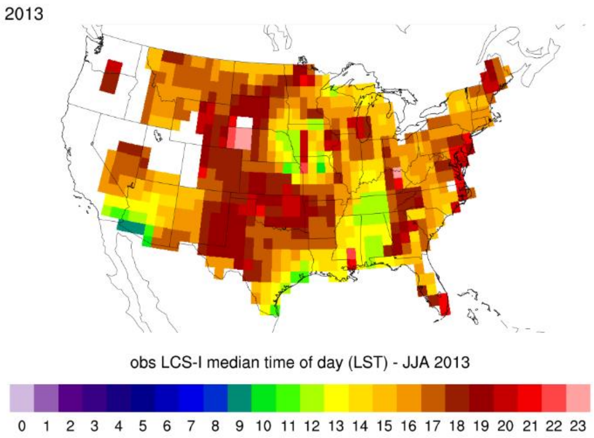
Frequency of Large Scale CI

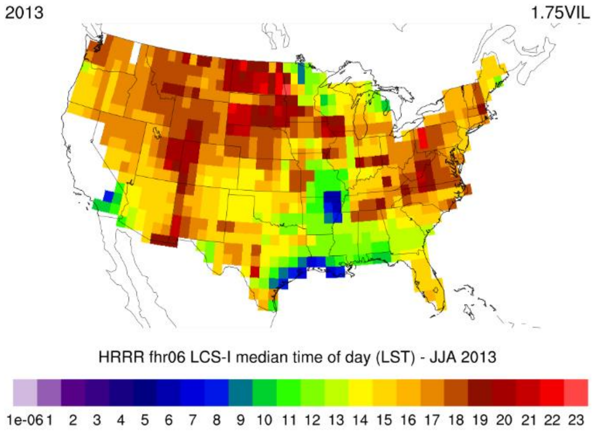
Observed

Modeled – 6 hour fcst

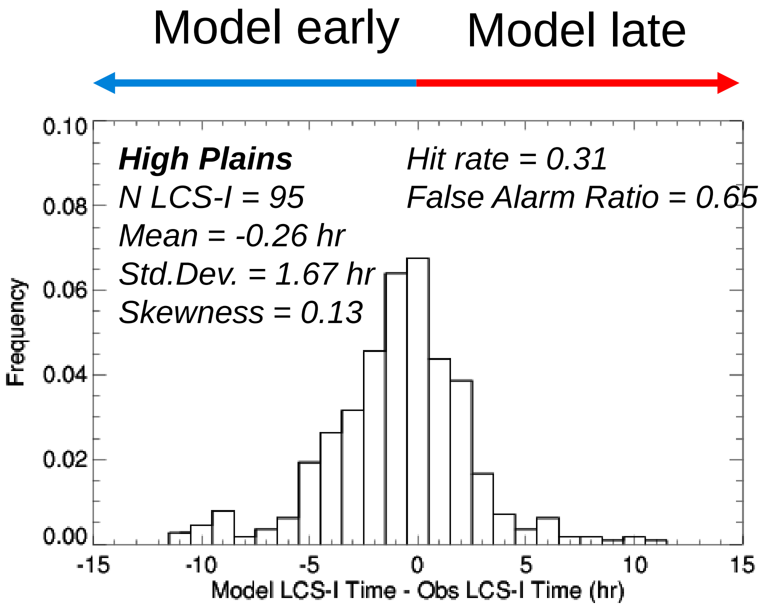








Model Performance – Matched Objects



Matching criteria - within 250 km and 3 hours

Improving the Understanding and Prediction of Nocturnal Convection through Advanced Data Assimilation and Ensemble Simulations for PECAN

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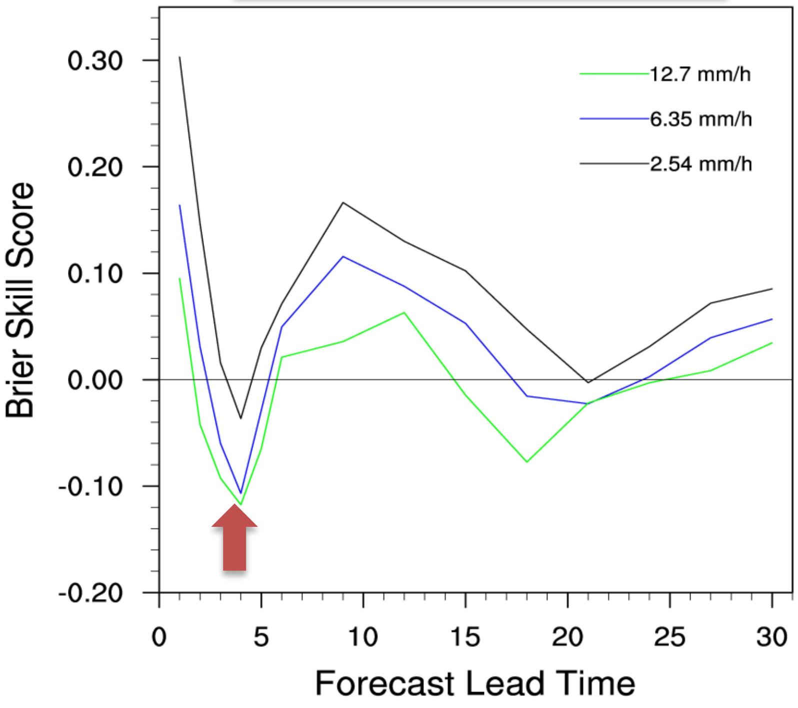
PECAN PLANNING MEETING
May 12-14, 2014, Boulder, CO

Background

2009 Spring Experiment PQPF



Johnson and Wang 2012, MWR

- ☐ a conceptual framework describing how elevated convection initiates and evolves in the presence of a SBL and a NLLJ is still lacking.

- ☐ An accurate prediction remains a challenge and requires:
  - Complete observations that adequately sample all scales involved;
  - A NWP model that can adequately represent the physical processes that govern the initiation and evolution of nocturnal convection across these multiple scales;
  - An advanced data assimilation system that can effectively combine such observations with the numerical model to provide accurate initial conditions;
  - An advanced ensemble prediction system that can effectively sample errors of the forecasts.

Objectives

- Participating field-phase of PECAN through generation of real-time convection-permitting ensemble forecasts initialized using an advanced ensemble-based DA and ensemble forecast system (e.g., initialized from 12Z and 18Z, and provided in real time to support the forecast preparation at 19Z and 02Z planned for the field phase).

- Assimilate special field experiment observations to assess the role that the unique PECAN observation systems play in improving predictive skill.

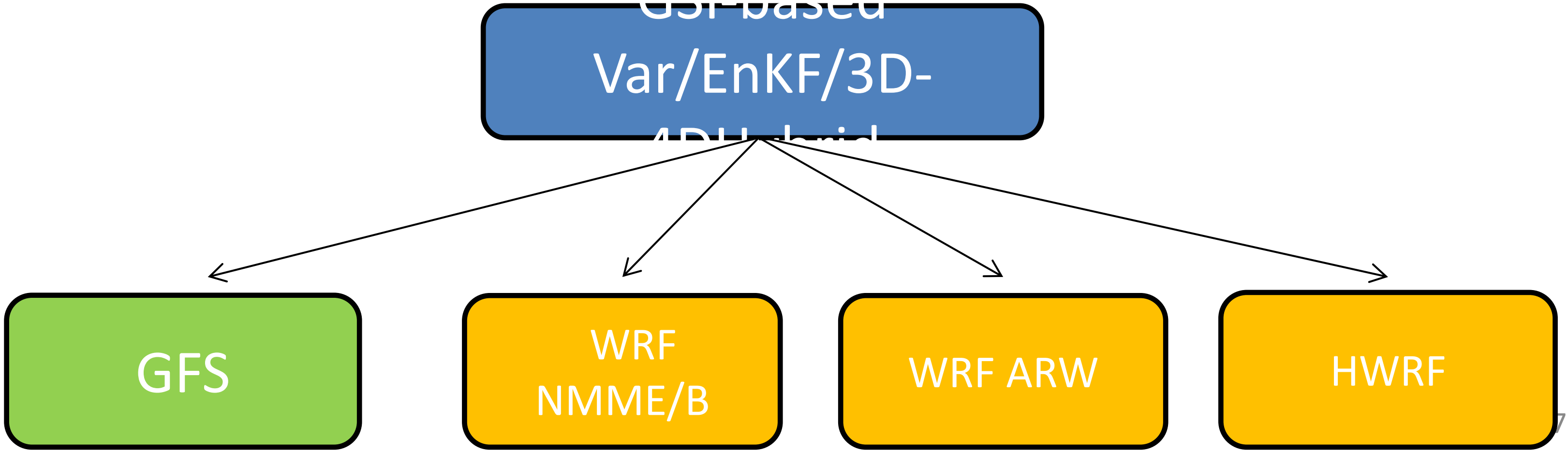
- Comprehensively diagnose the ensemble analyses and simulations to determine the dynamical and physical processes that initiate and maintain nocturnal convective systems and control their structure and evolution.

- Comprehensively evaluate ensemble analyses and forecasts against special PECAN observations to determine the appropriate modeling strategies (e.g., grid spacing; parameterization of physical processes, ensemble design) for improved prediction.

Approaches

- ❑ DA and EF System:
- ◆ DA: The GSI-based, multiscale, ensemble based DA system for WRF ARW
- ◆ EF: Ensemble generated by the perturbed initial condition inherent in the ensemble DA, multiple physics/stochastic Kinetic backscatter, and perturbed lateral boundary.

- ❑ Linkage to operational NWP: The DA (Var/EnKF/hybrid) system developed based on NWS operational DA system GSI is further extended and tested with regional, meso/convective scale modeling systems, following operational implementation of the hybrid DA at NCEP for GFS on May 22, 2012 (e.g., Wang, Kleist, Parrish, and Whitaker 2013, MWR).



GSI-based Var/EnKF/3D-4DHybrid

GFS

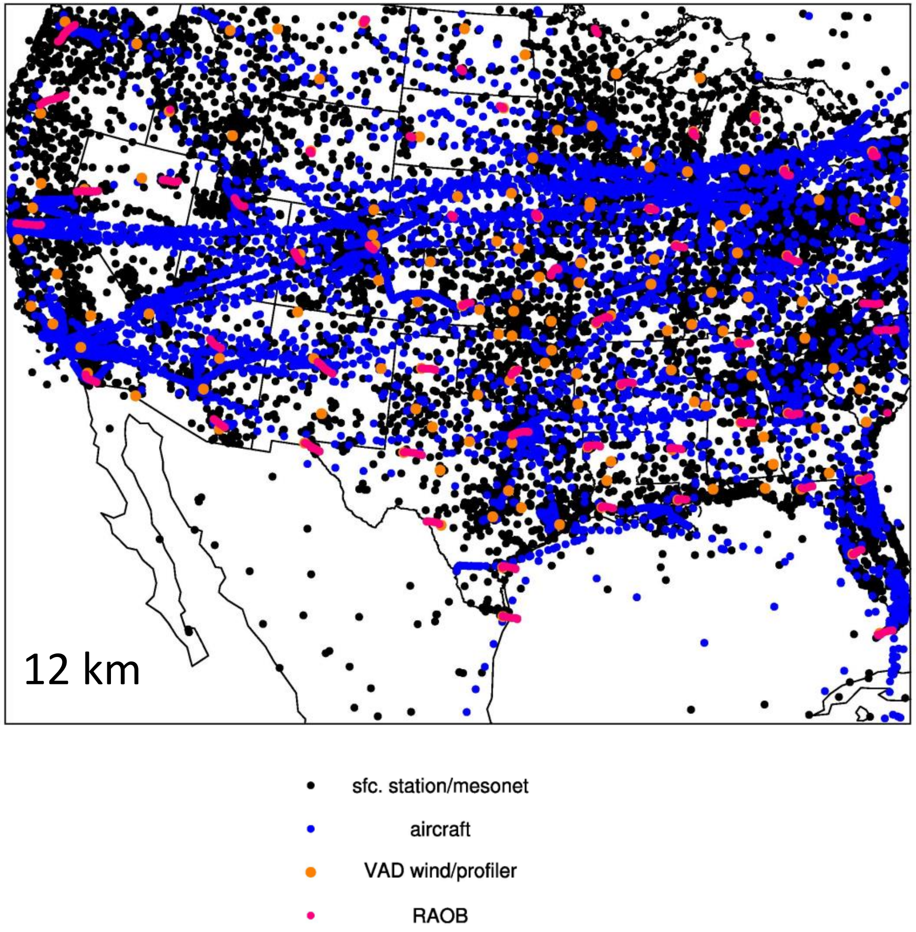
WRF NMME/B

WRF ARW

HWRF

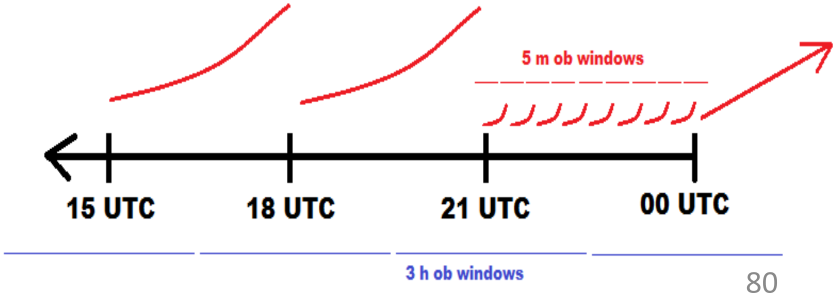
Multi-scale data assimilation & ensemble forecast system

U observations assimilated at 00 UTC 20 May

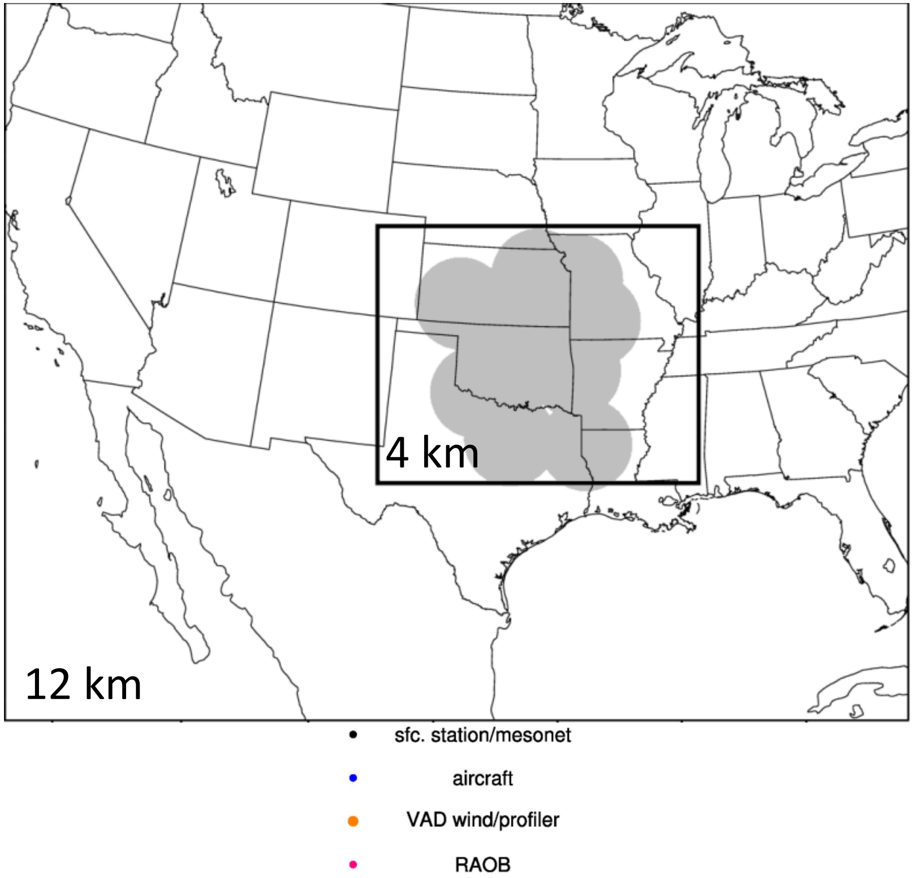


Johnson, Wang et al. 2014

- **Outer Domain**
  - Currently assimilate operational conventional surface and mesonet observations, RAOB, wind profiler, ACARS, and satellite derived winds every 3 hours to define synoptic/mesoscale environment
  - Add and assimilate PECAN obs.

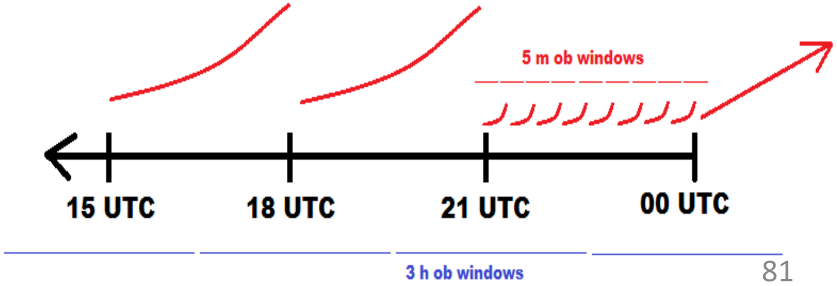


Multi-scale data assimilation & ensemble forecast system

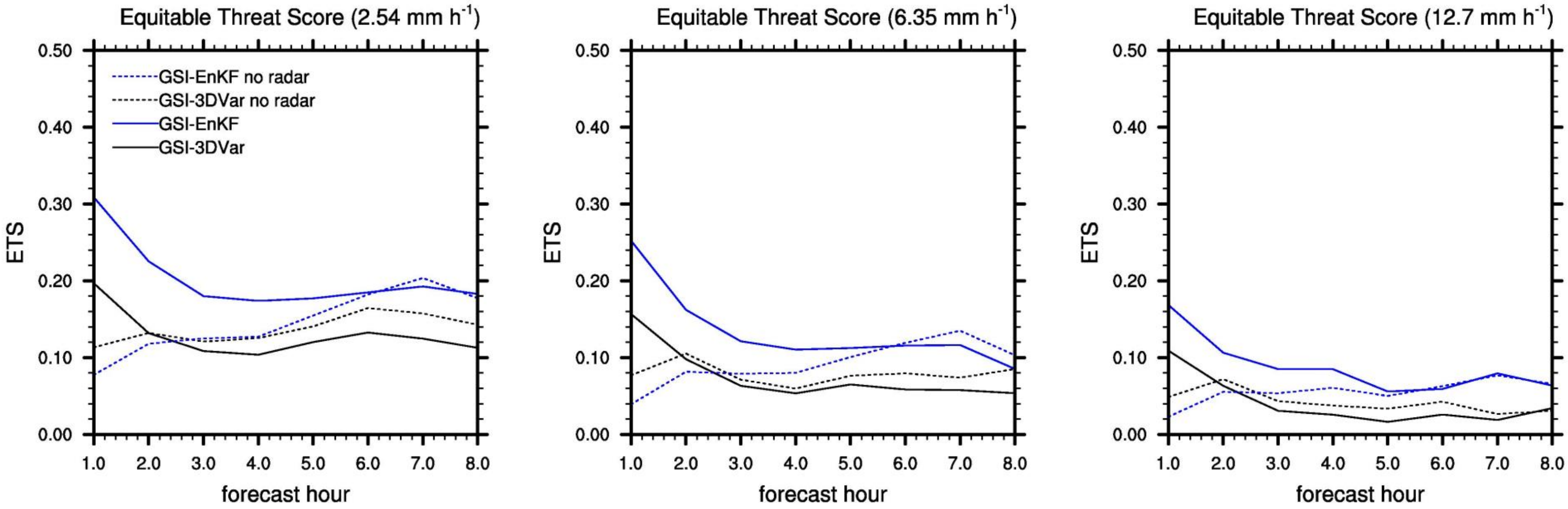


- **Inner Domain**
  - Currently assimilate velocity and reflectivity from NEXRAD radar network every 5 min during last 3hr cycle
  - Add and assimilate PECAN obs.

- Outer domain analysis cycle provides IC/LBCs for



Precipitation forecast skill averaged over 10 complex, convectively active cases



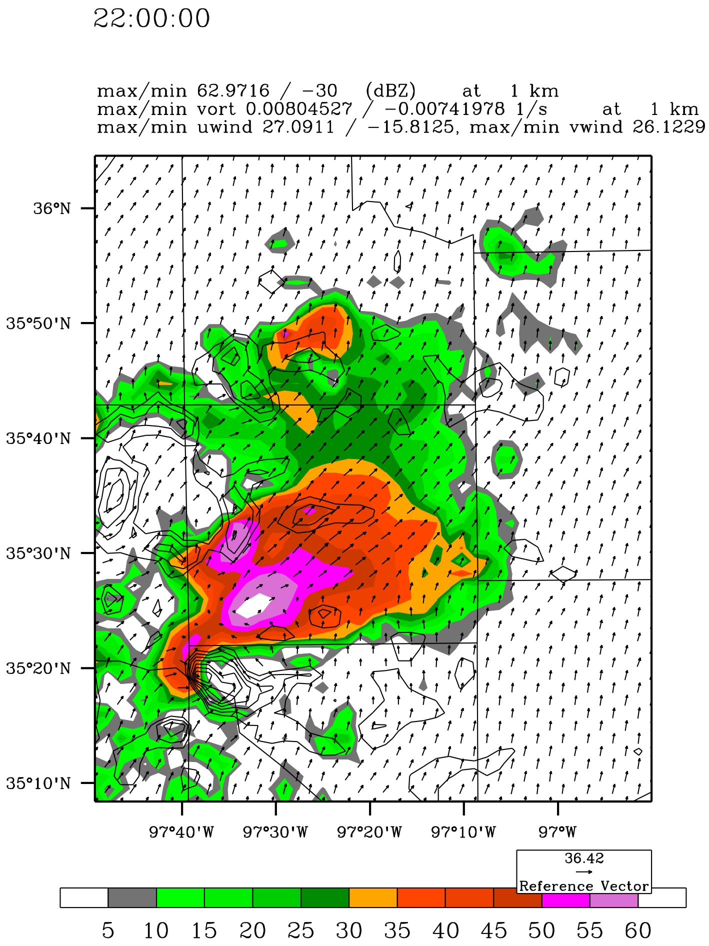
Equitable Threat Score (2.54 mm h^{-1})

Equitable Threat Score (6.35 mm h^{-1})

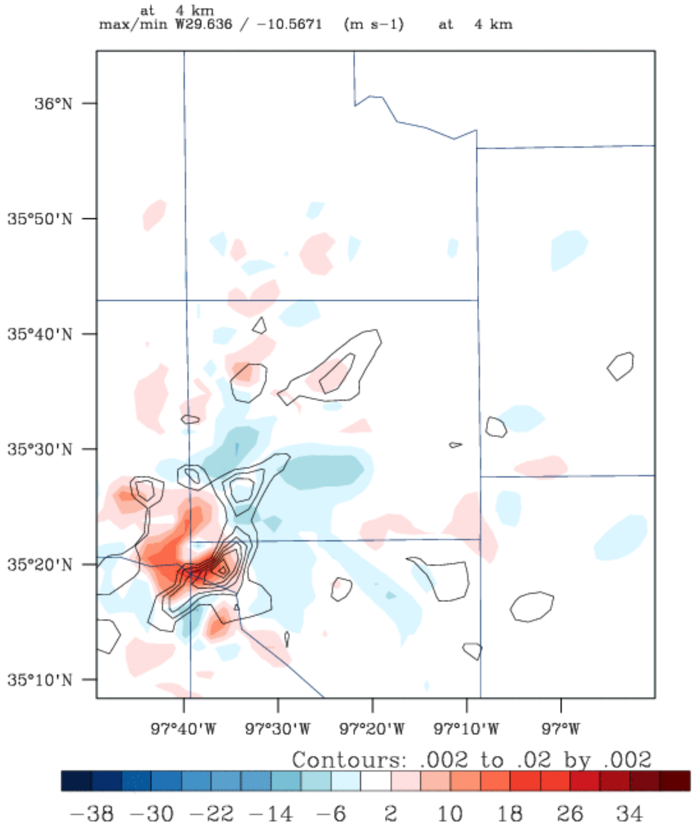
Equitable Threat Score (12.7 mm h^{-1})

- GSI-EnKF forecasts are more skillful than GSI-3DVar forecasts for all thresholds and lead times.
- Benefits of radar data are more pronounced assimilated by GSI-EnKF than GSI-3DVar.

May 8th 2003 OKC Tornadic Supercell



1hr forecast from 22Z



Ref and vorticity at 1 km

W and Vort. at 4 km

Lei, Wang et al. 2014