UAlbany Scientific Results & Interests:

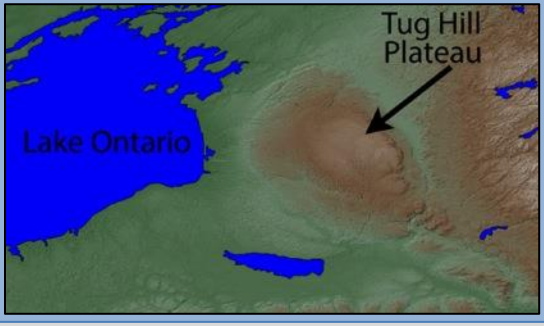
Convective evolution in LLAP bands from profiling radars and numerical simulations

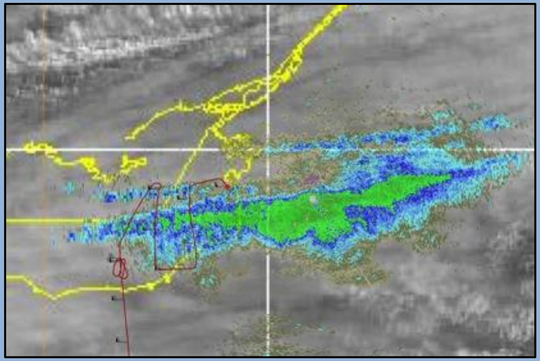
Justin Minder & Ted Letcher
(in close collaboration with Steenburgh group @ UUtah)

What determines downwind evolution of LLAP bands & their snowfall?

Mesocale forcings:

- Orography
- Surface heat fluxes
- Surface momentum fluxes



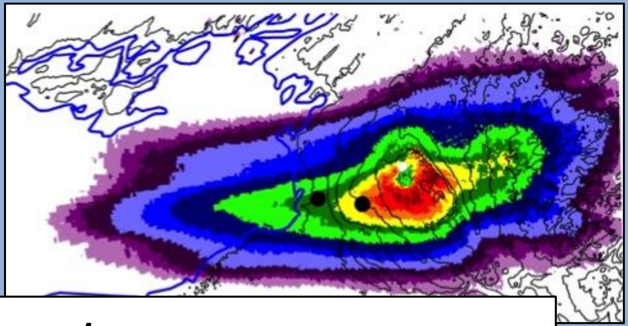


Convective scale dynamics:

- **Cloud depth**
- **Turbulence**
- **Vertical velocities**
- **Horizontal scales/structures**
- Buoyancy

Cloud & precipitation structures:

- In-cloud ice and supercooled water
- **Spatial and temporal distribution of snowfall rate**

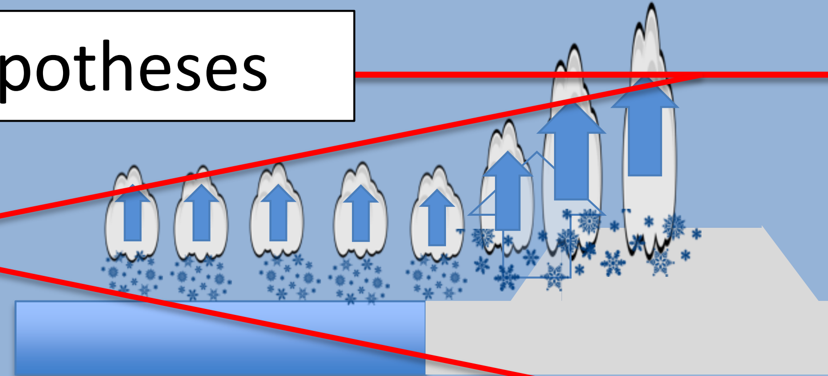


What is required to adequately resolve or parameterize this evolution in numerical models?

Plausible hypotheses

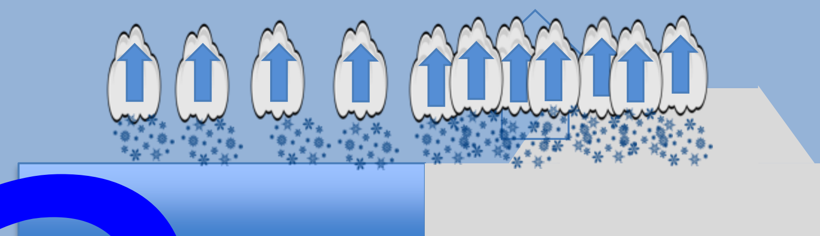
~~Orographic lifting "invigorates" convection~~

- ~~*occurs for mountainous islands in Caribbean trade-winds (Kirshbaum & Smith 2009, Kirshbaum & Grant 2012)*~~



Orographic lifting produces more "populous" convective cells

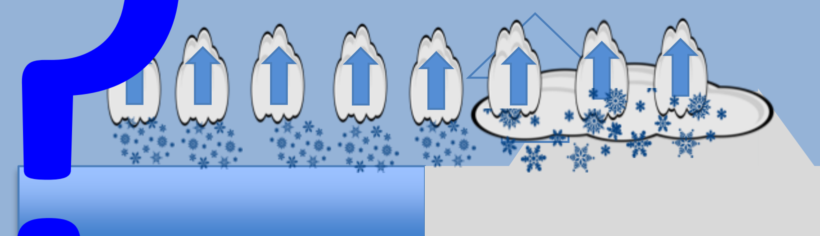
- *occurs for mountainous islands in Caribbean trade-winds (Kirshbaum & Smith 2009, Kirshbaum & Grant 2012)*



?

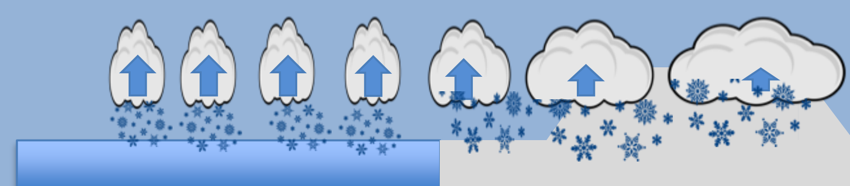
Orographic lifting creates stratiform "cap-cloud", enhancing snowfall by collisional growth

- *"seeder-feeder" variant*



Downwind clouds are more "efficient" at producing snowfall.

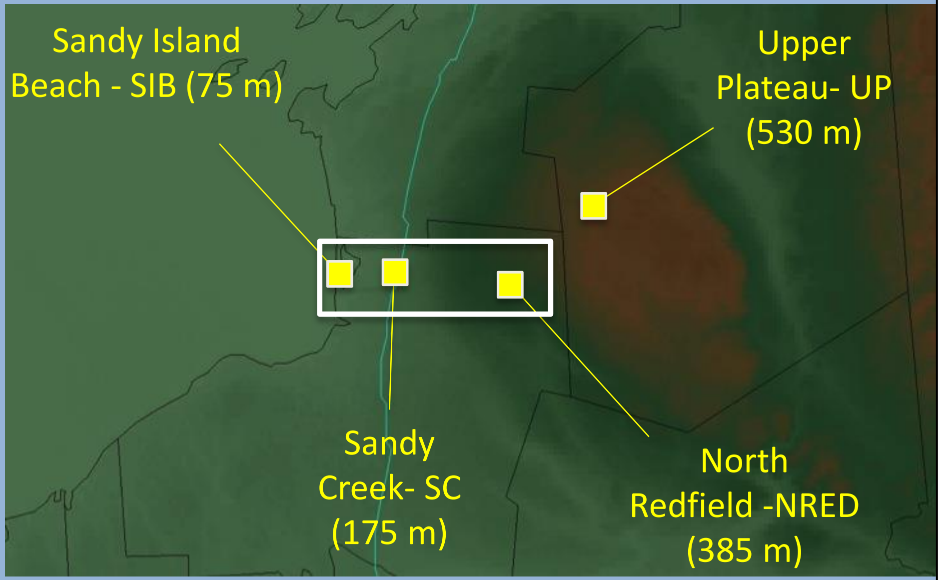
- *buoyancy loss? mesoscale convergence? cloud size? stratiform transition?*



Observations

Goals

- *Characterize along-band variations in convective structure with high temporal and veritcal resolution*
- *Look for robust patterns and interesting variations*



4 Micro Rain Radars (MMR2's)

- 24 GHz, FM-CW, profiling, Doppler
- Δz= 200 m
- max. height = 6km
- Δt =10 s

Deployment

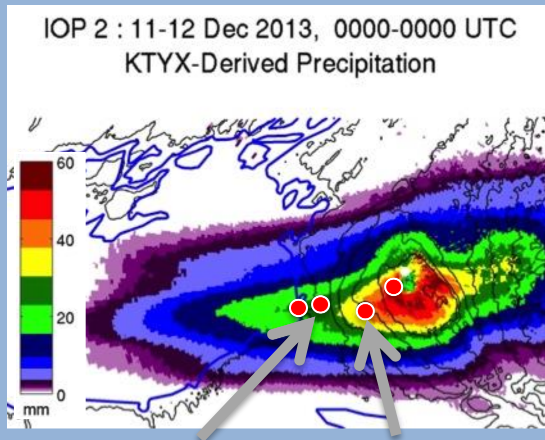
- IOP-phase: Dec-Jan (All sites)
- Extended : Oct-Feb (SIB & NRED)

Post-processed

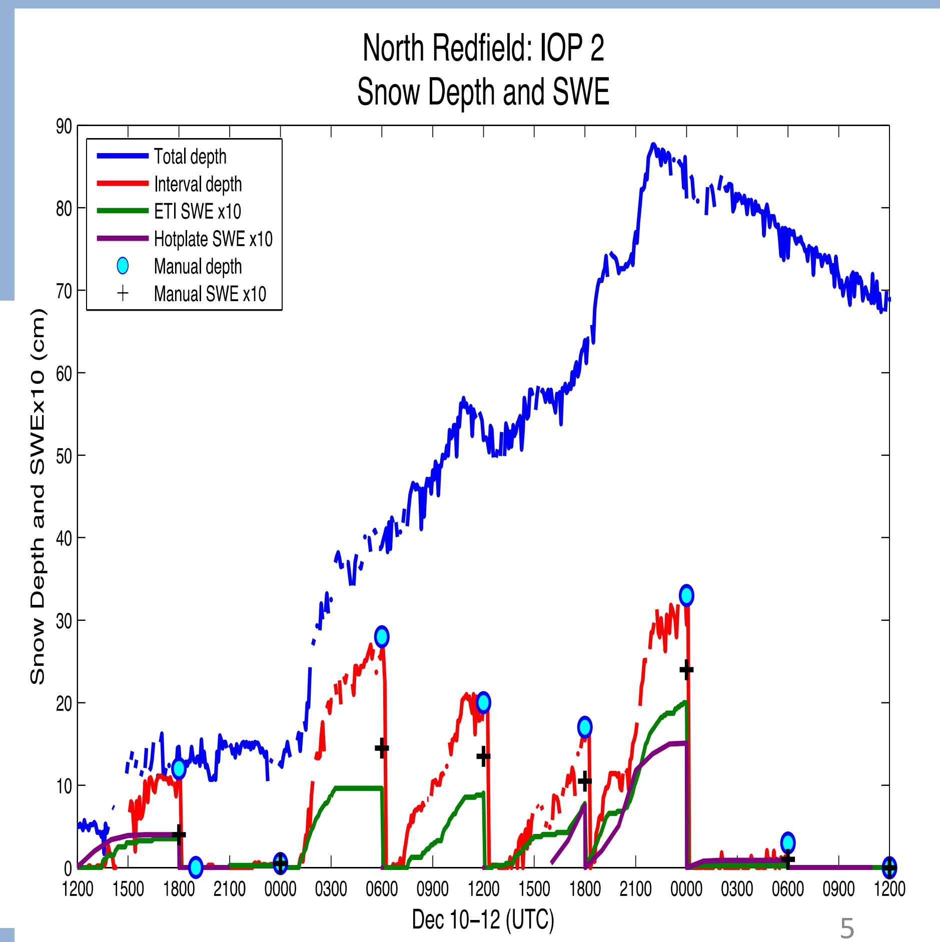
- following Maahn & Kollias (2012)
- Improves sensitivity, removes noise, dealiases velocities, better treatment of snow

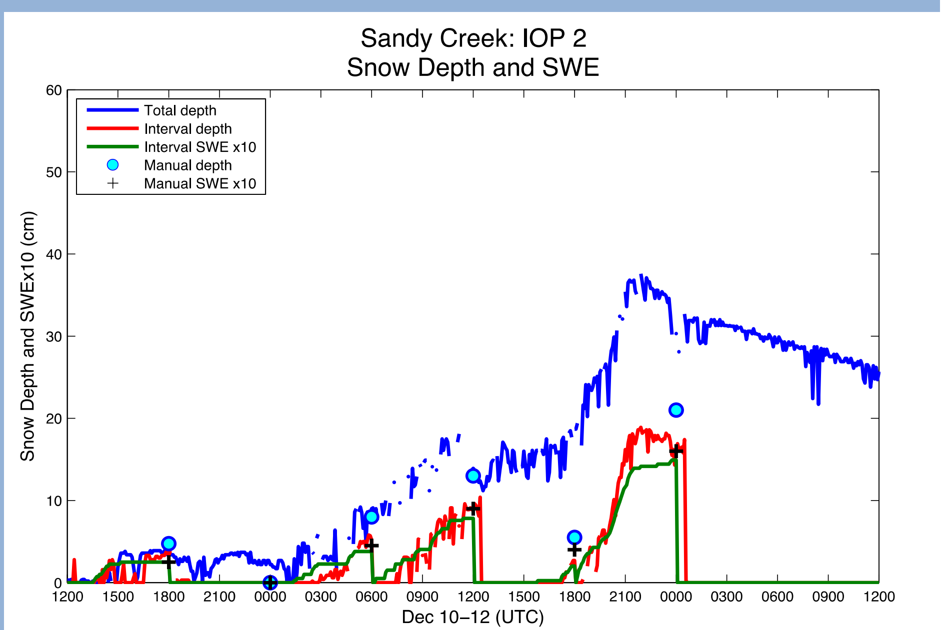
Co-located radars for inter-comparison before and during the field campaign

Case-study example: IOP2b

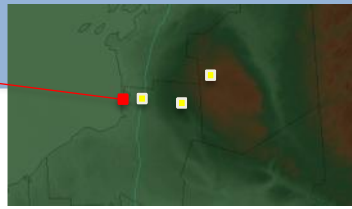


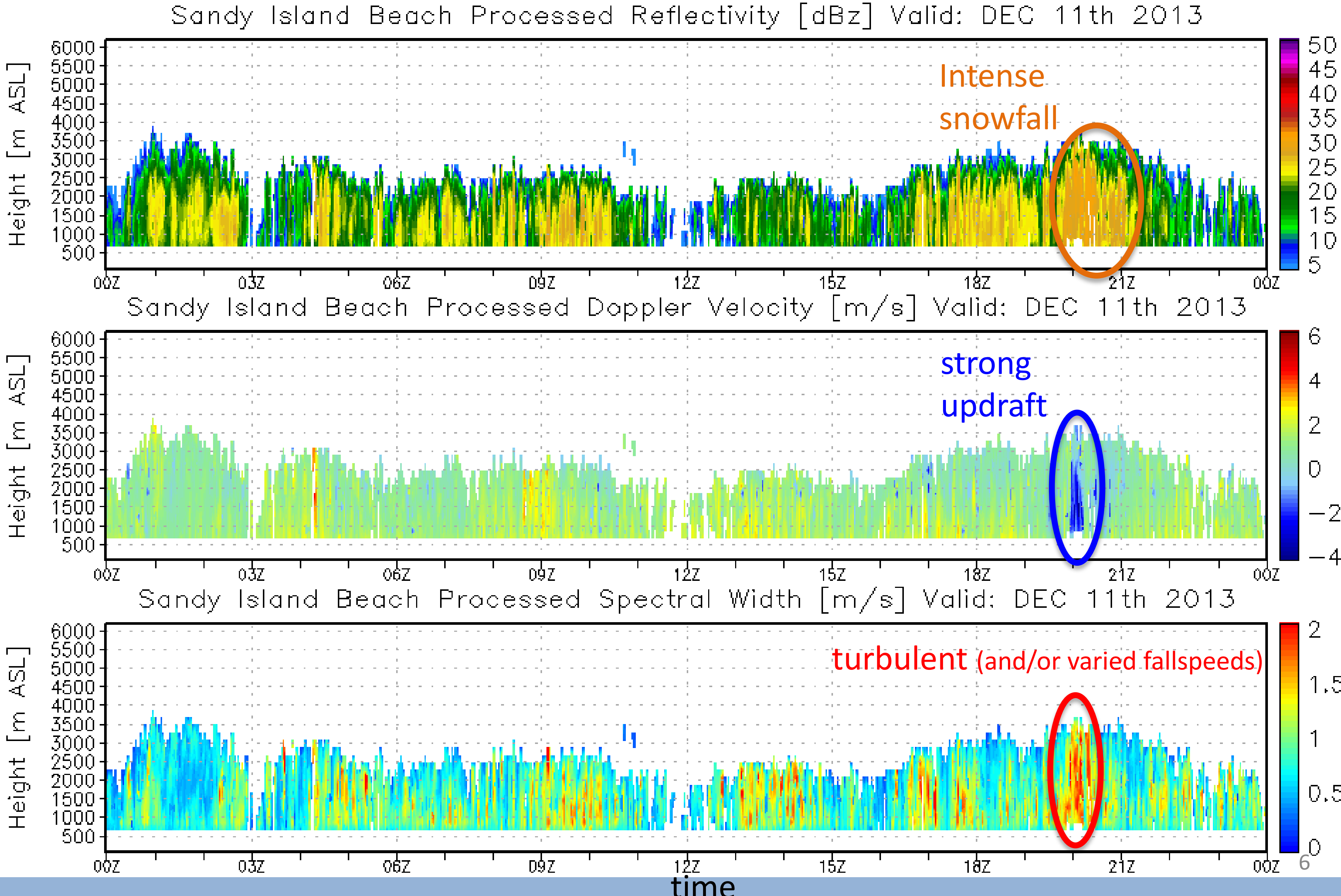
SC: 33.5 mm NRED: 62.5 mm



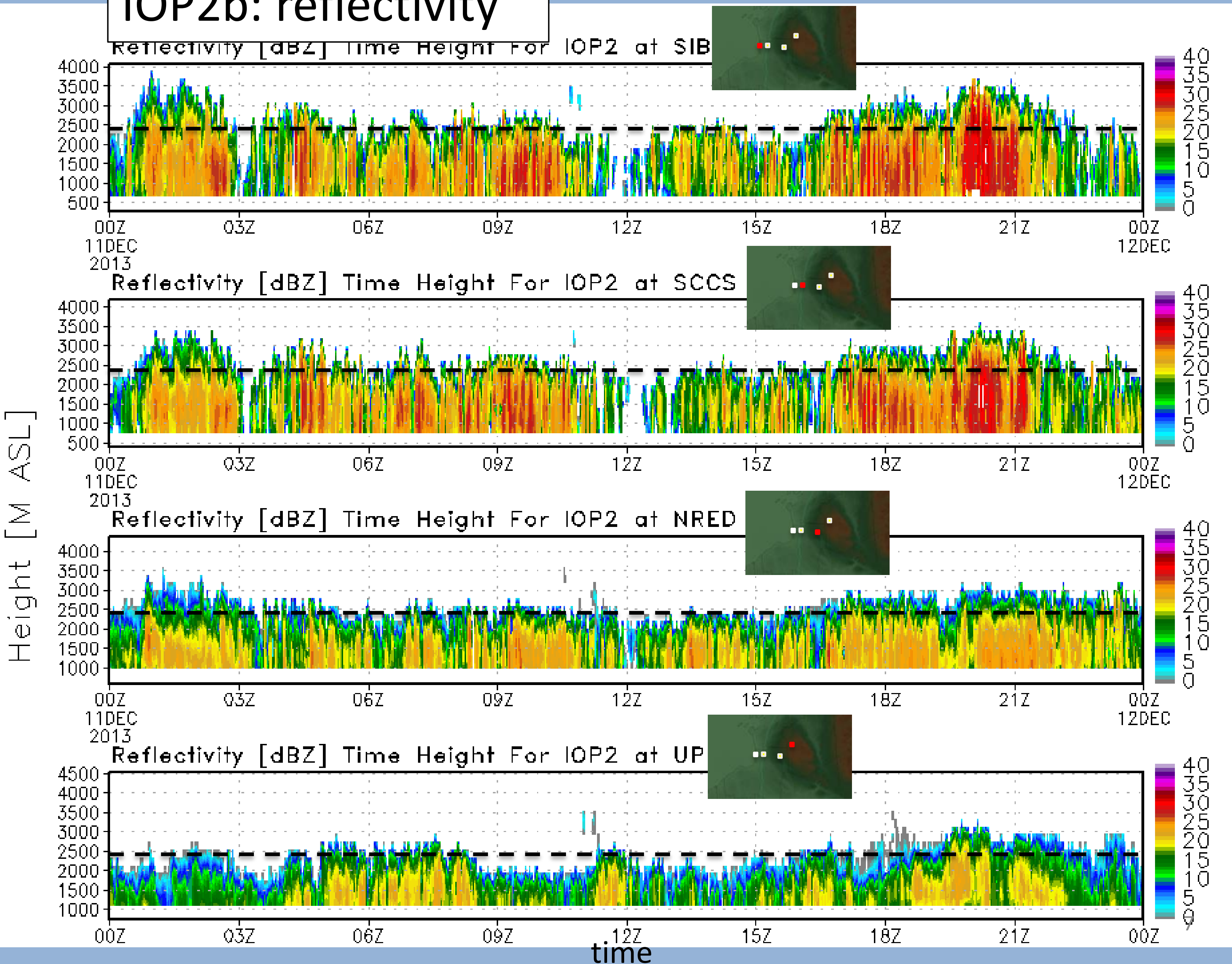


Case-study example: IOP2b

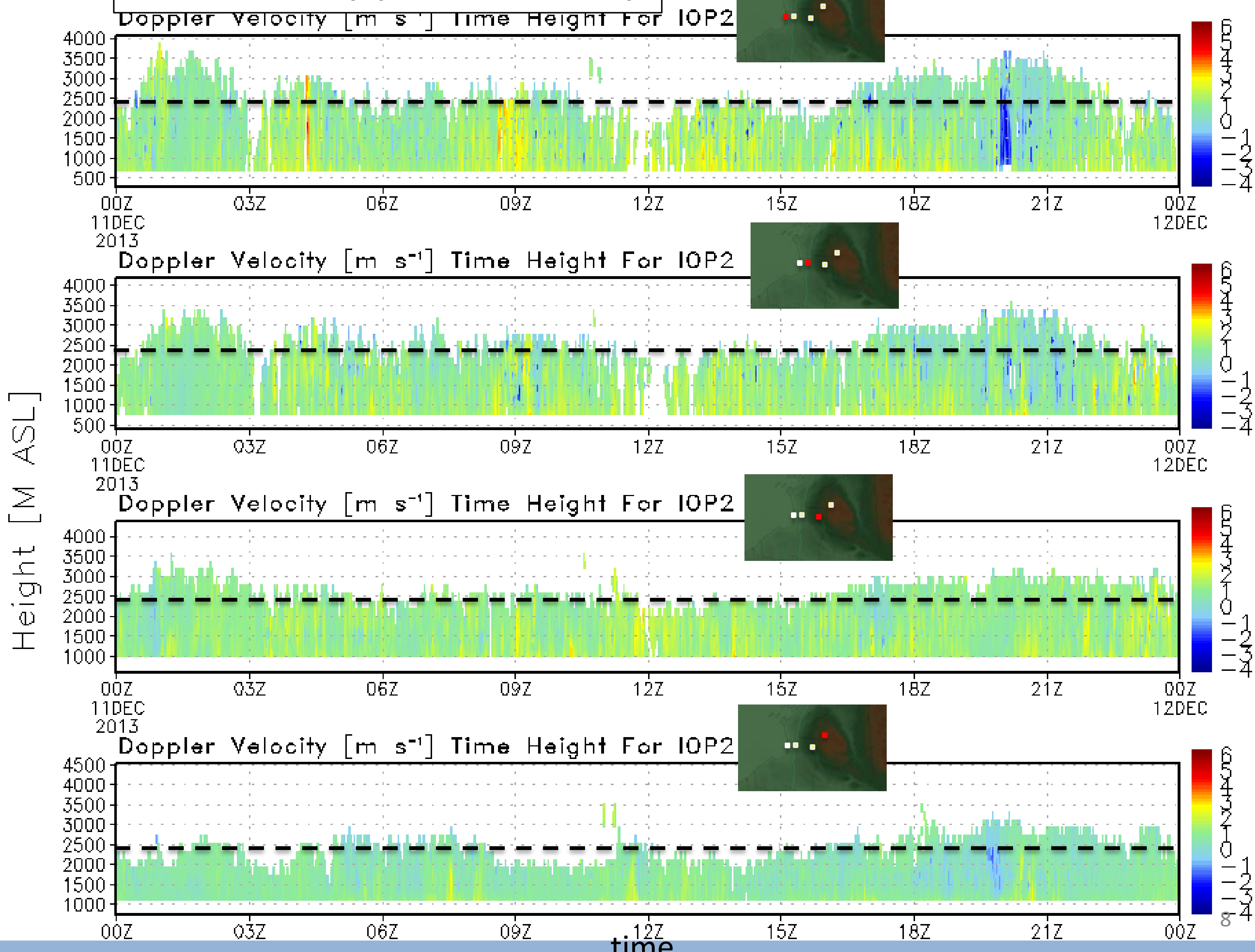




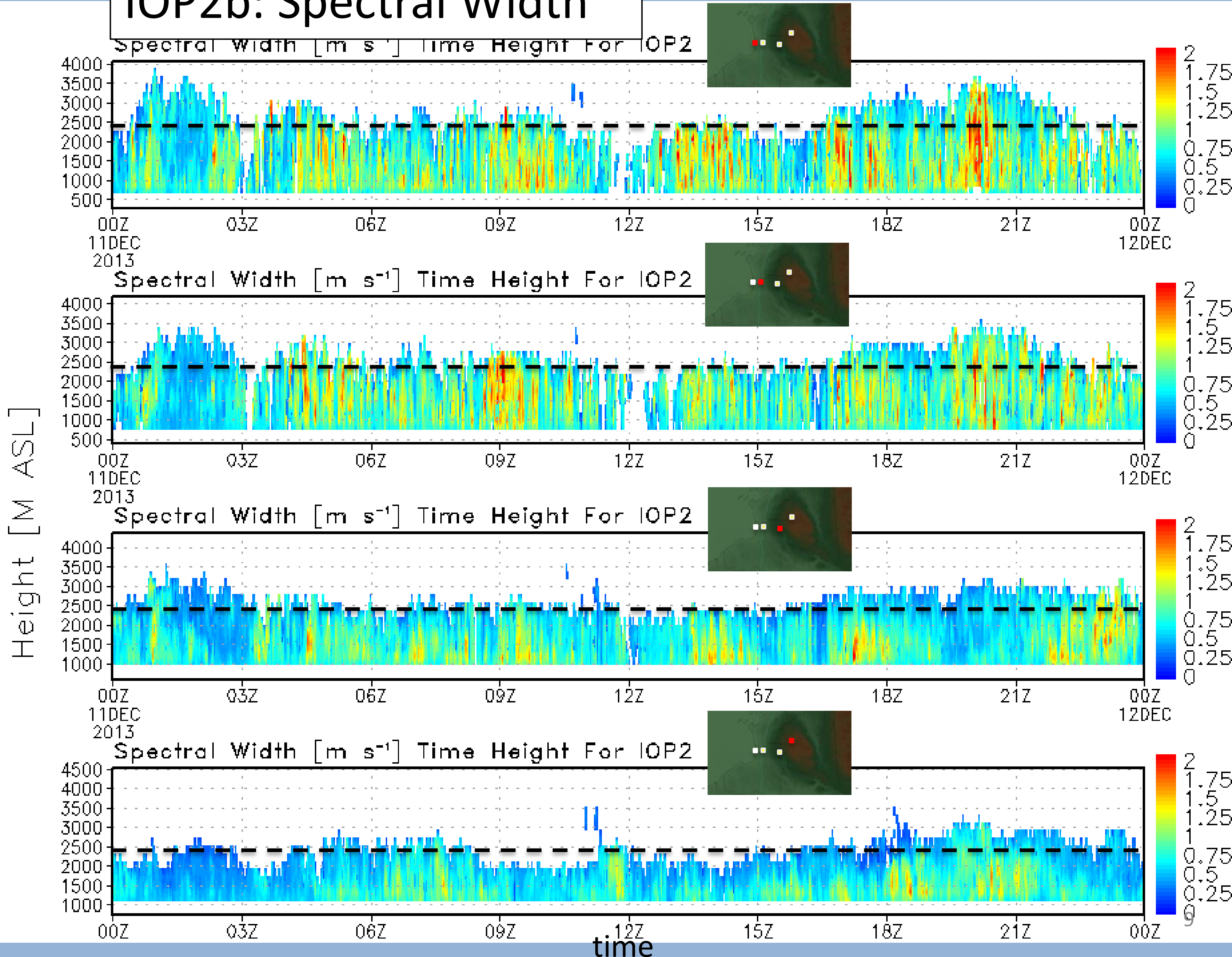
IOP2b: reflectivity



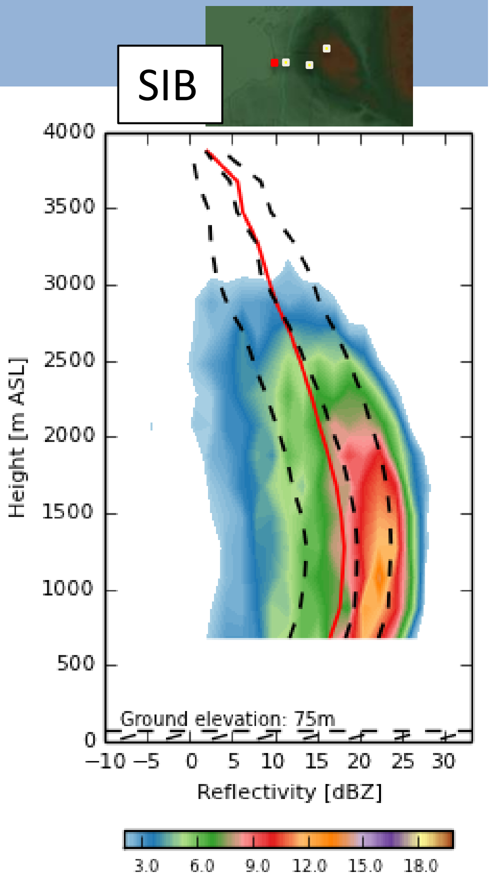
IOP2b: Doppler Velocity



IOP2b: Spectral Width

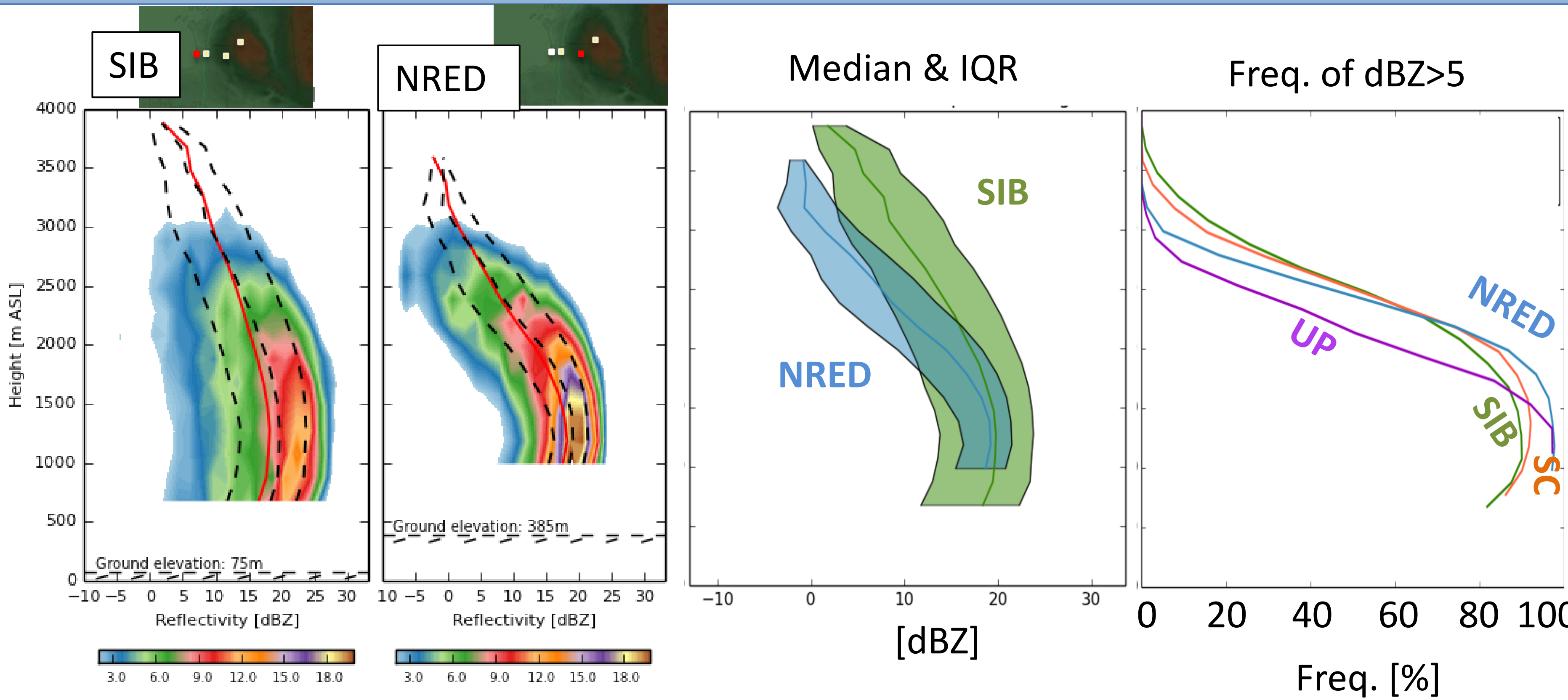


IOP2b: dBZ Contoured Frequency by Altitude Diagrams (CFADs)



[% / dBZ]

IOP2b: Downwind evolution of CFADS
SIB vs. NRED



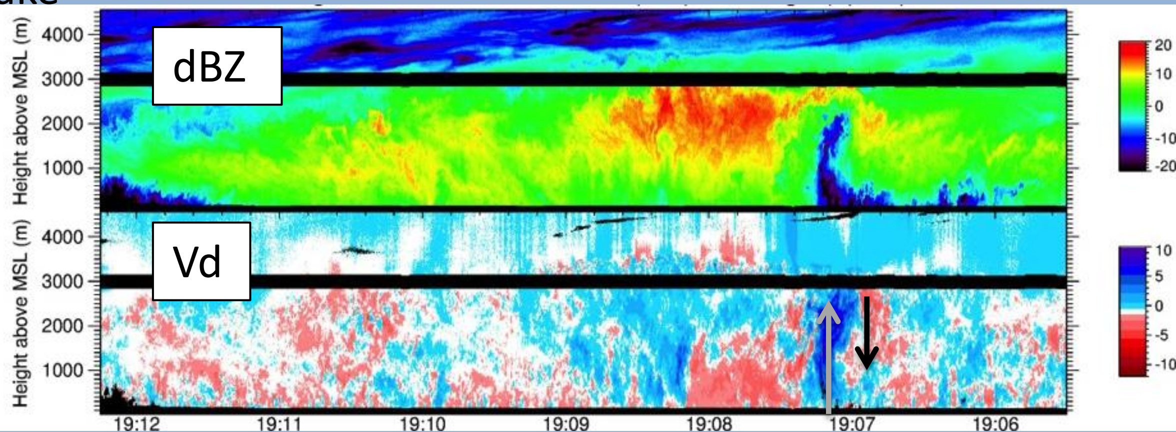
@ NRED:

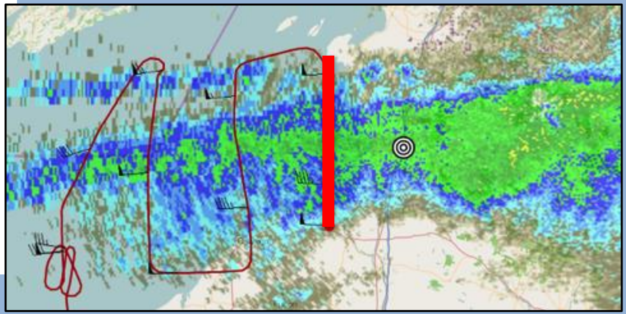
- Larger vertical gradient in dBZ
- Narrower distribution of dBZ
- Less frequent echoes aloft
- More frequent low-level echoes
- No evidence of sub-cloud sublimation

IOP2b: Downwind evolution seen by WCR

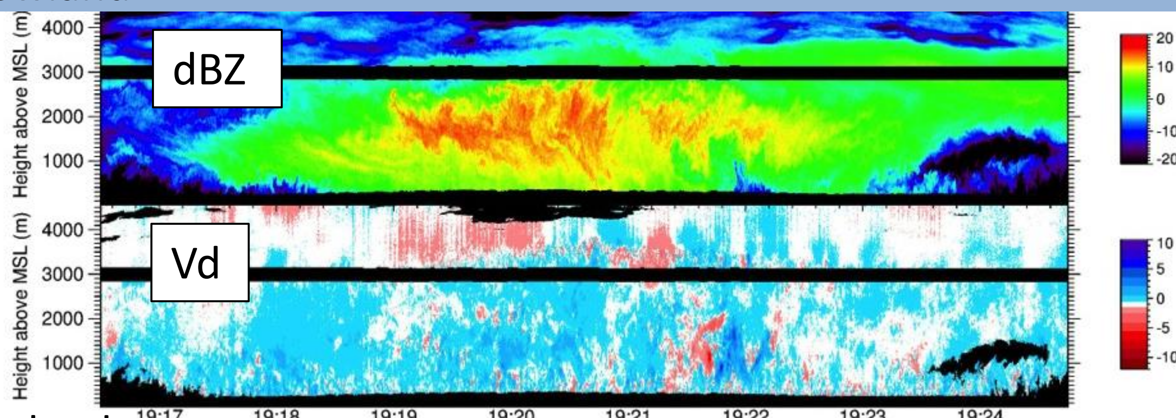
South North

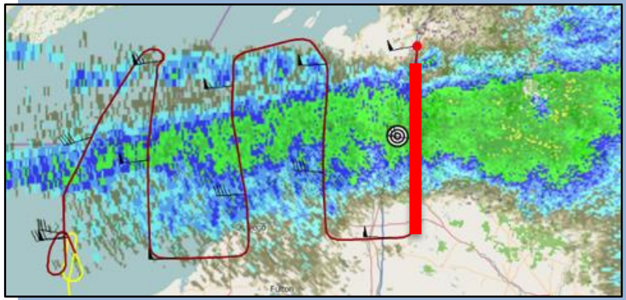
Lake



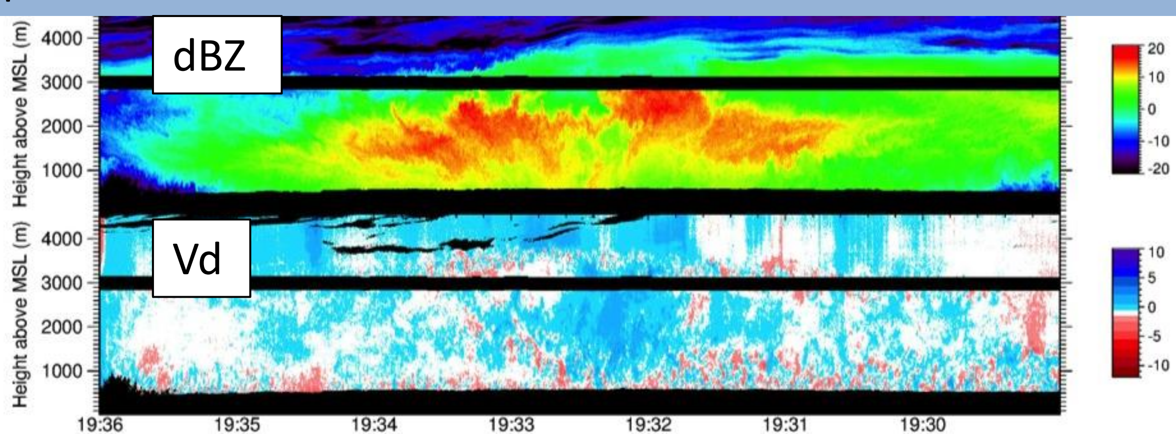


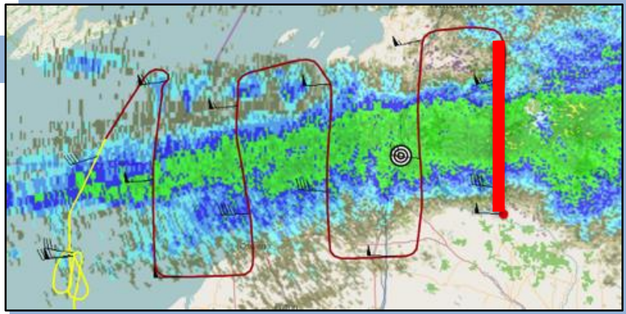
Lowland





Upland

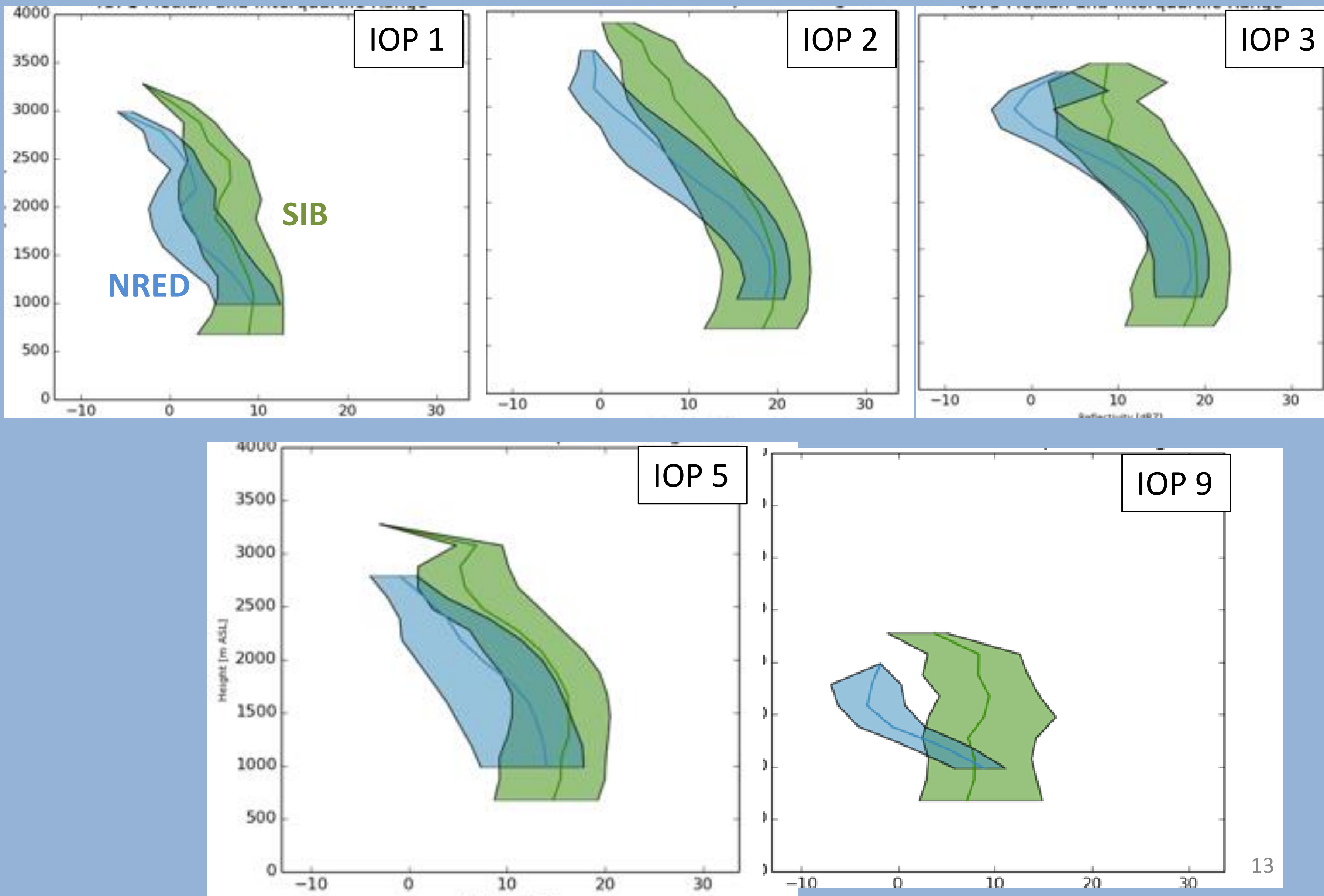




Note the color key, centered at -1 ms-1 rather than at 0 ms-1, to approximately account for the hydrometeor fall speed, such that blue (red) regions can be interpreted as updrafts (downdrafts).

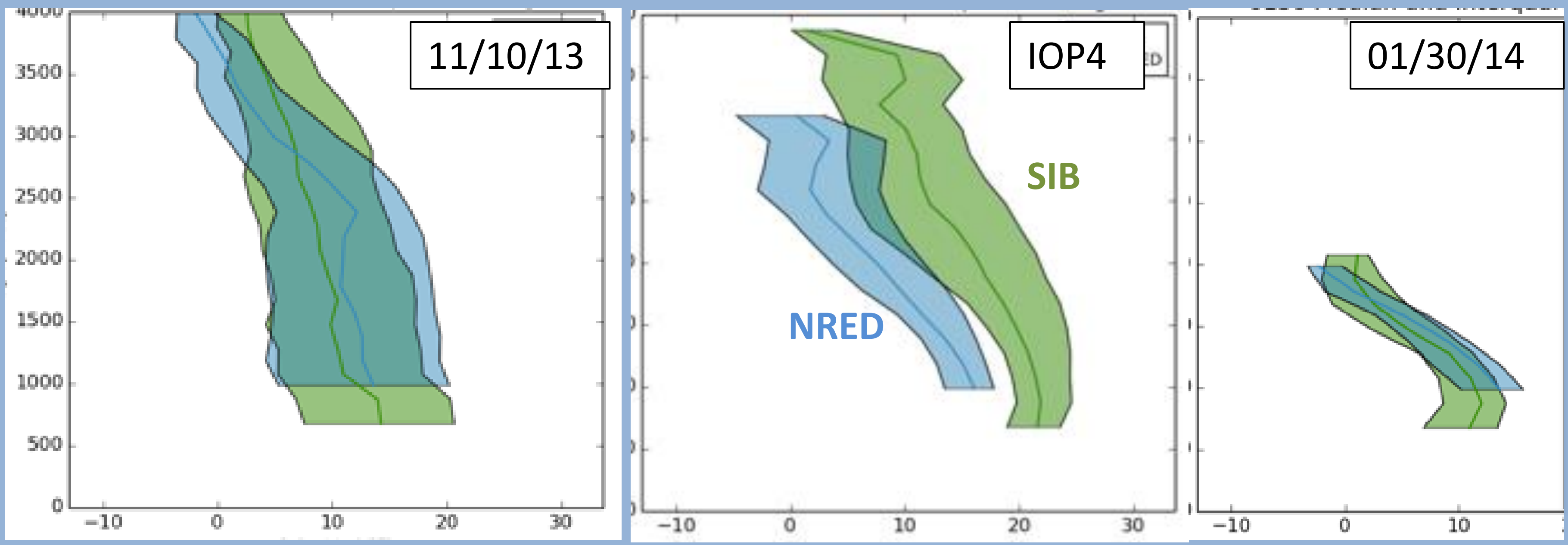
Common evolution between SIB & NRED for many IOPs

Median & IQR

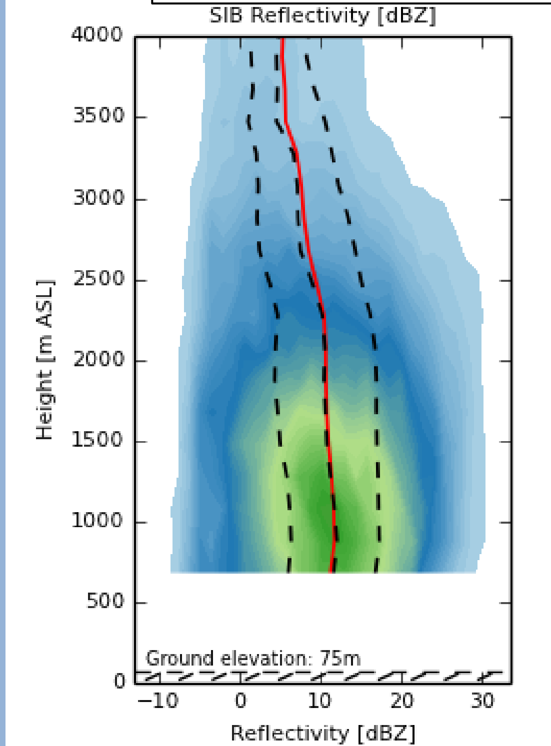


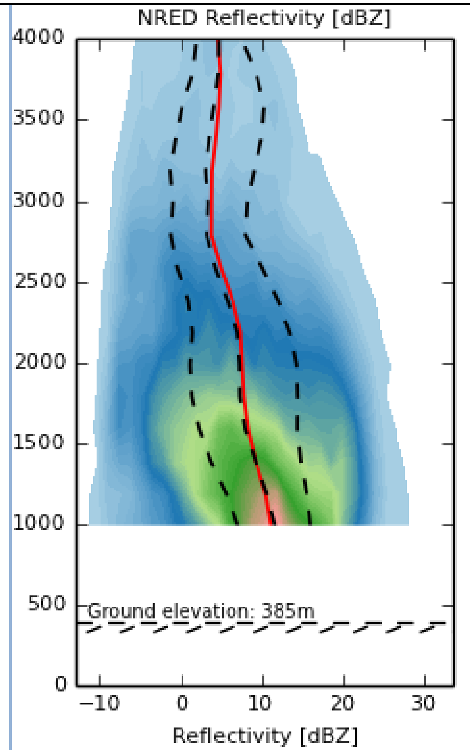
…but not always

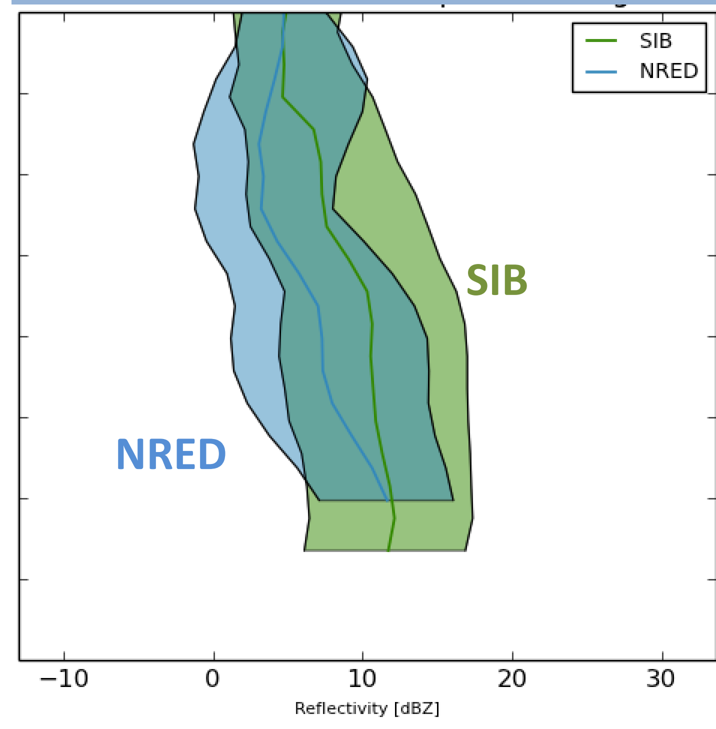
Median & IQR



Bulk CFADS for *all* LLAP events observed @ SIB & NRED



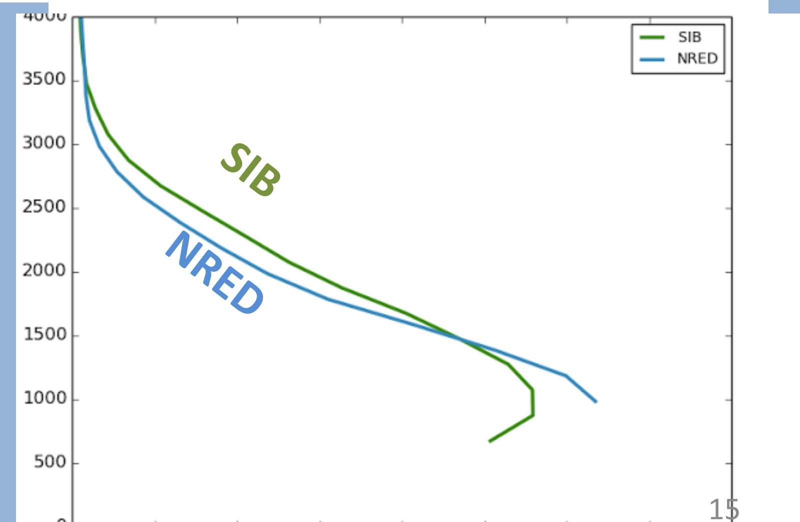




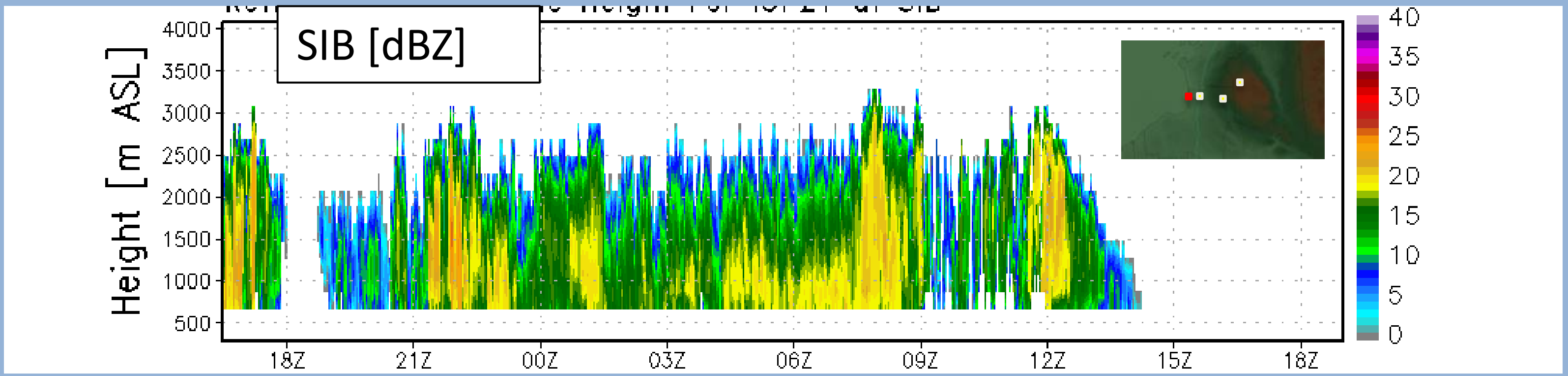
17 LLAP events (Nov 2013-Feb 2014)

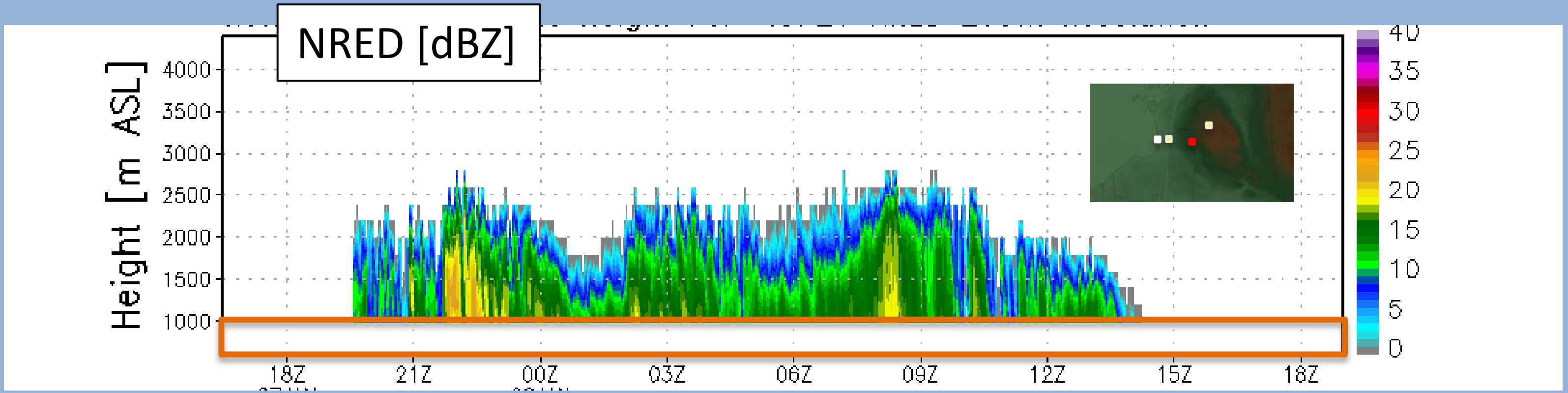
Same along-band evolution seen in IOP 2:

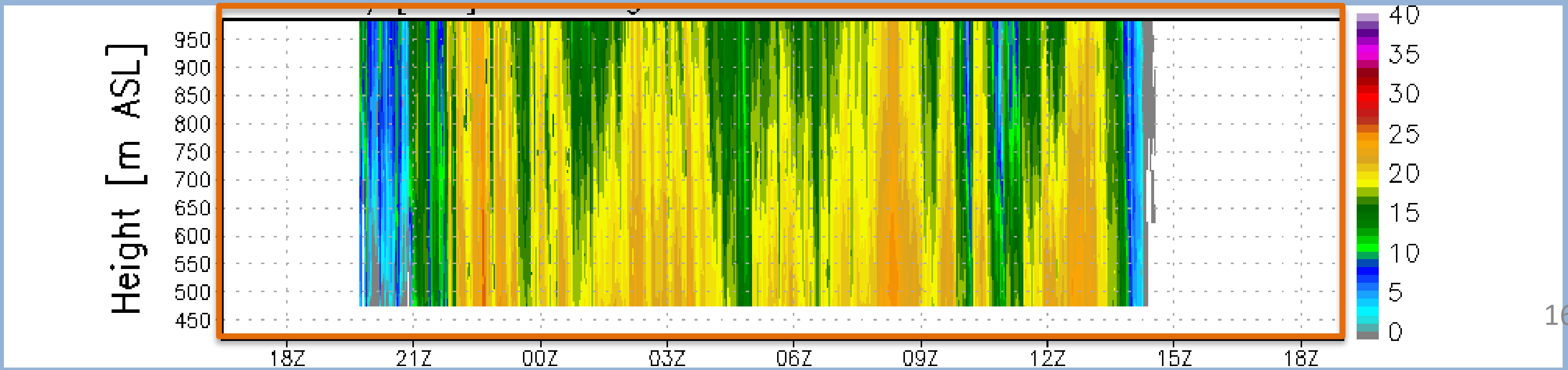
- Reduced varability
- Reduced dBZ aloft
- Increased low-level echo frequency
- Loss of sublimation signature



IOP 21: Evidence for intense low-level growth?

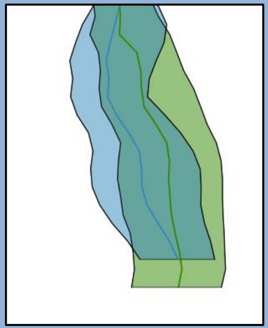


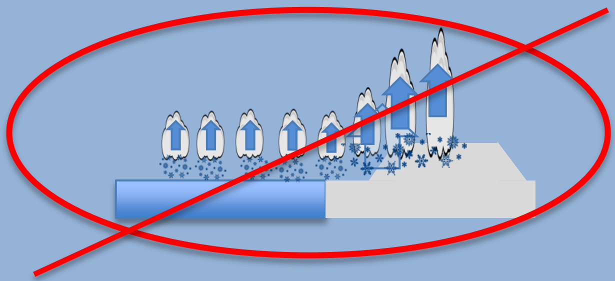




Conclusions (thusfar)

Time-height structure of convection typically exhibits a common change in structure between shore and Tug Hill

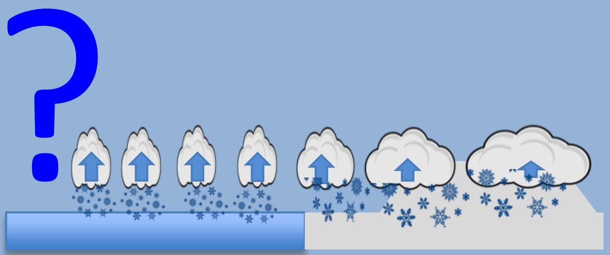


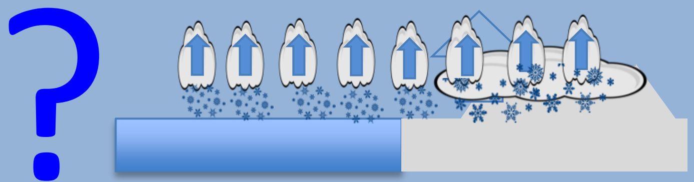


Orographic "invigoration" of convection is not responsible for Tug Hill precip maximum

Compared to upwind, echoes over the Tug are often:

- weaker aloft
- more-frequent near the ground
- Shallower
- less-turbulent

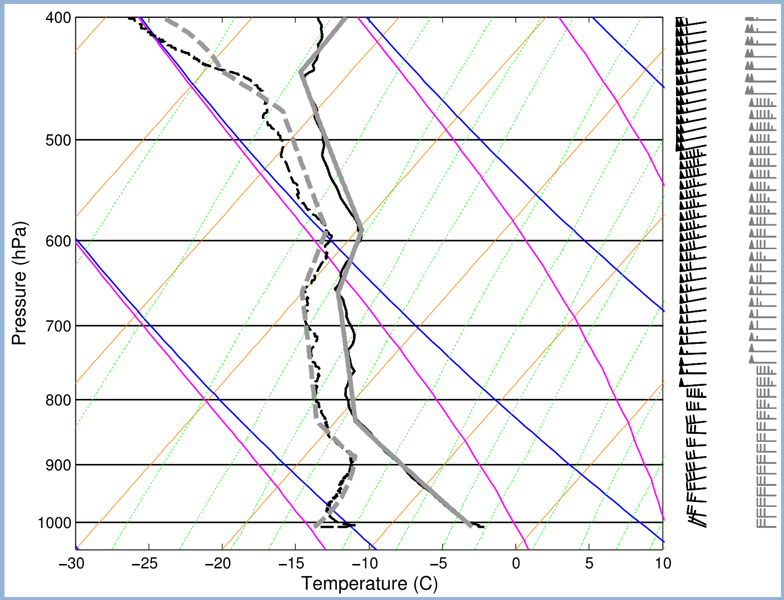




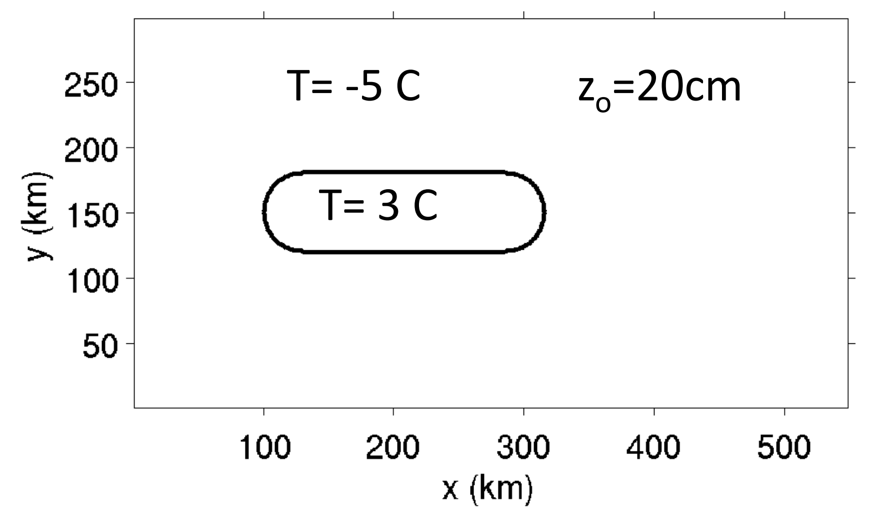
Hints of strong low-level growth in orographic "feeder" cloud?

(Initial) Semi-idealized modeling efforts

Motivation
- *Want modeling framework suitable for controlled experiments*
- *Want ability to resolve & analyze convective scale features*
- *Remove all but most-essential features*

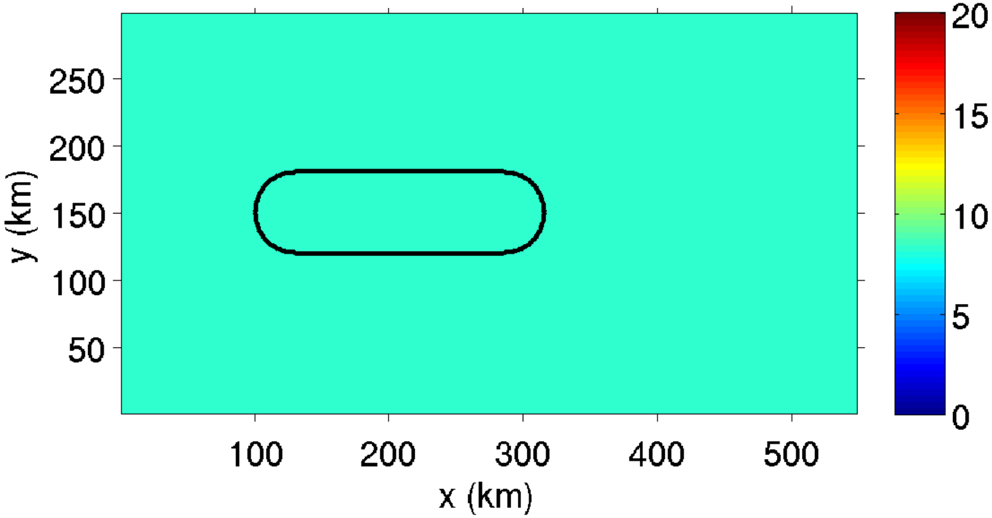


Setup
- WRF v3.5
- Initialized from Dec. 11 1755 UTC Darl. Sounding
- Periodic BC's to N & S.
- Damping layer to E & W.
- No radiation, no PBL scheme
- Surface heat, moisture, momentum fluxes parameterized (M-O similarity theory)
- Thompson Microphysics
- Simulations w/ and w/o "Tug"
- Run to ~ steady-state

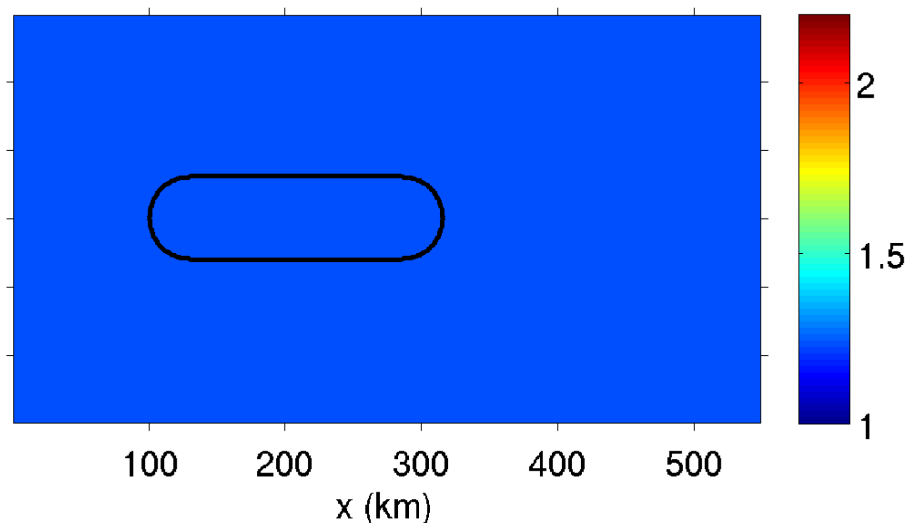


Initial simulation results (no "Tug")

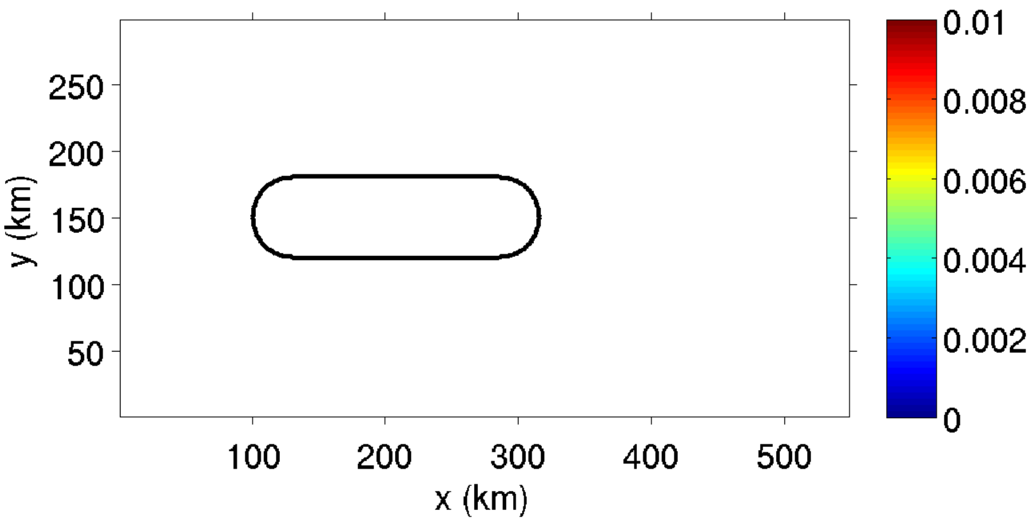
Surface u-wind (m/s)



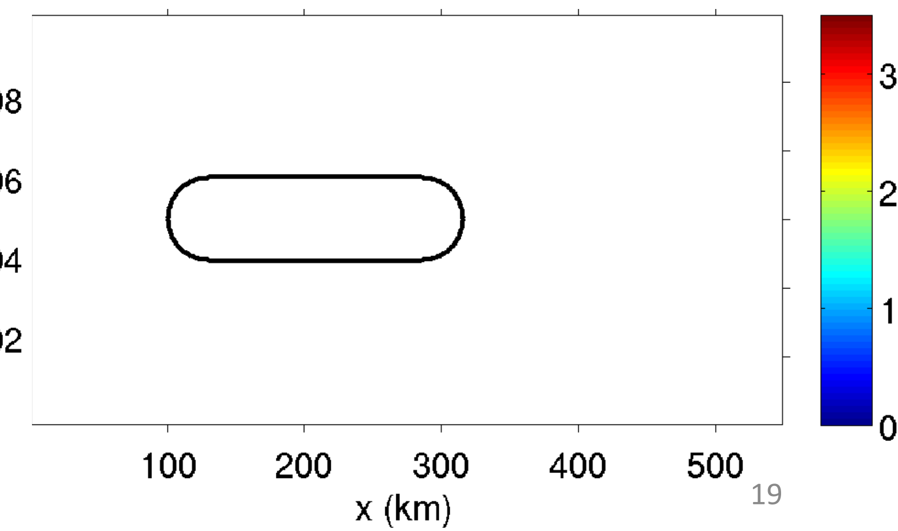
Surface q_v (g/kg)



q_i at z=2.5km (g/kg)



Surface snow rate (mm/hr, liq. equiv)



Future plans (& potential collaborations)

Near-term:

- Contextualize “downstream evolution” of LLAP band convective structure seen by MRR’s with aircraft data, surface crystal habits, DOW observations (UUtah, UWyo?, CSWR?)
- Detailed analysis of convective transition and precipitation enhancement mechanisms using semi-idealized cloud-resolving model simulations (UUtah, Uwyo?, others?)
- Try to understand storm-to-storm variations in MRR-observed structures and their relation to along-band precipitation variations (UUtah, others?)

Other possibilities:

- Use semi-idealized cloud-resolving simulations for testing various OWLeS-motivated hypotheses (?).
- Happy to share MRR2 data and work with others who have interests in multi-frequency radar analysis, comparison, or QPE (UAH?, CSWR?, UWyo?)

The New York State Mesonet

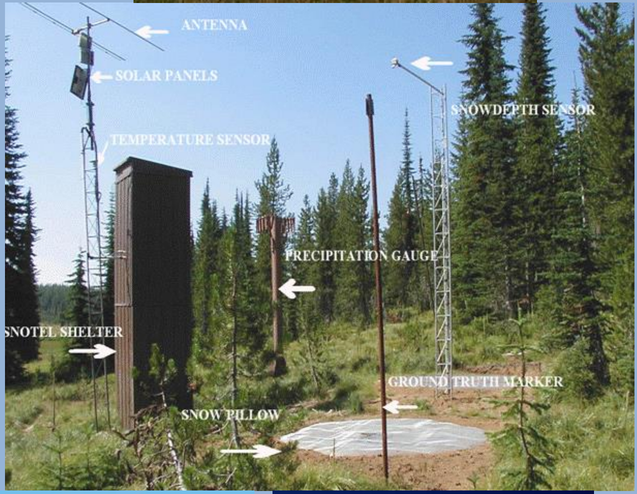
- “NYS Early Warning Weather Detection System”
- Lead by Ualbany (with NYS-DHSES & NWS)
- Improved observational infrastructure and operational products
- Wide range of applications, but disaster preparedness is key
- Governer Cuomo (& Vice President Biden) announced on Jan 7, 2014.
- Funded under Sandy Disaster Relief Program
- Close collaborations with Consultation with OK-mesonet, NCAR, & others
- 3-year “build-out”
- Currently hiring (Director & Postdoc, more positions to come)

The New York State Mesonet

~125 surface automated weather stations
- High quality and carefully sited
- 2 & 10-m winds, T, RH
- Solar radiation
- Surface pressure
- Soil moisture
- **Weighing precipitation gauge with wind shield**

~20 enhanced "snow sites"
- All of the standard variables plus…
- **Sonic snow depth**
- **Snowpack SWE**
- Mainly in Adirondacks (& on Tug Hill)

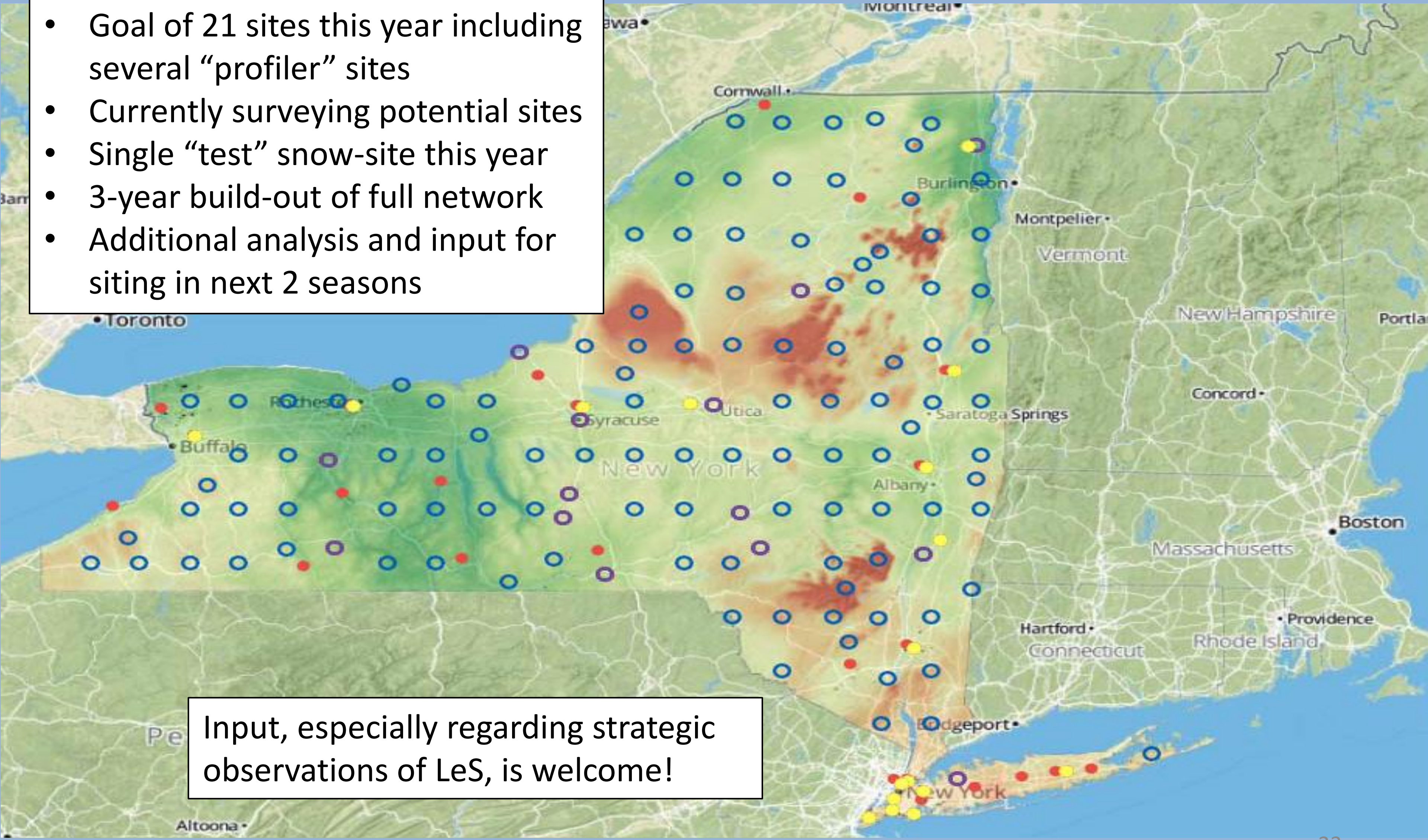
~15 enhanced "profiling sites"
- All of the standard variables plus…
- **Lidar wind profiler**
- **Microwave radiometer**
- 4-component surface radiation
- Near most major cities (& select strategic locations)



The New York State Mesonet

Schematic **showing approximate station density (NOT ACTUAL SITE LOCATIONS!!!)**

<u>Plans:</u>
- Goal of 21 sites this year including several "profiler" sites
- Currently surveying potential sites
- Single "test" snow-site this year
- 3-year build-out of full network
- Additional analysis and input for siting in next 2 seasons



Input, especially regarding strategic observations of LeS, is welcome!