Transport and meteorological modeling products and services for SAS

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Outline:

- Why?
- WRF and FLEXPART
- Scales
- Existing products
- Planned products
- Our own science
- Uncertainty and evaluation
- How can we help you?

Why and what?

Lagrangian modeling aims to answer questions like:
Where did this air come from?
How long ago was it at location Z?
How much of species X was emitted from location Y?

WRF is the mesoscale meteorological model we use.
The term “WRF” is semantically null (means nothing by itself).
It’s a framework for a set of physics and numerics options.

FLEXPART is a Lagrangian Particle Dispersion Model.
It moves “particles” around according to the physical fields provided by WRF and its own internal parameterizations.
The displacement of each particle at each timestep has a deterministic (from the resolved winds) and a random component.
The result is a plume of particles or trajectories.
FLEXPART can be run forward or backward in time.
Backward runs are a very efficient way of interpreting measurements.

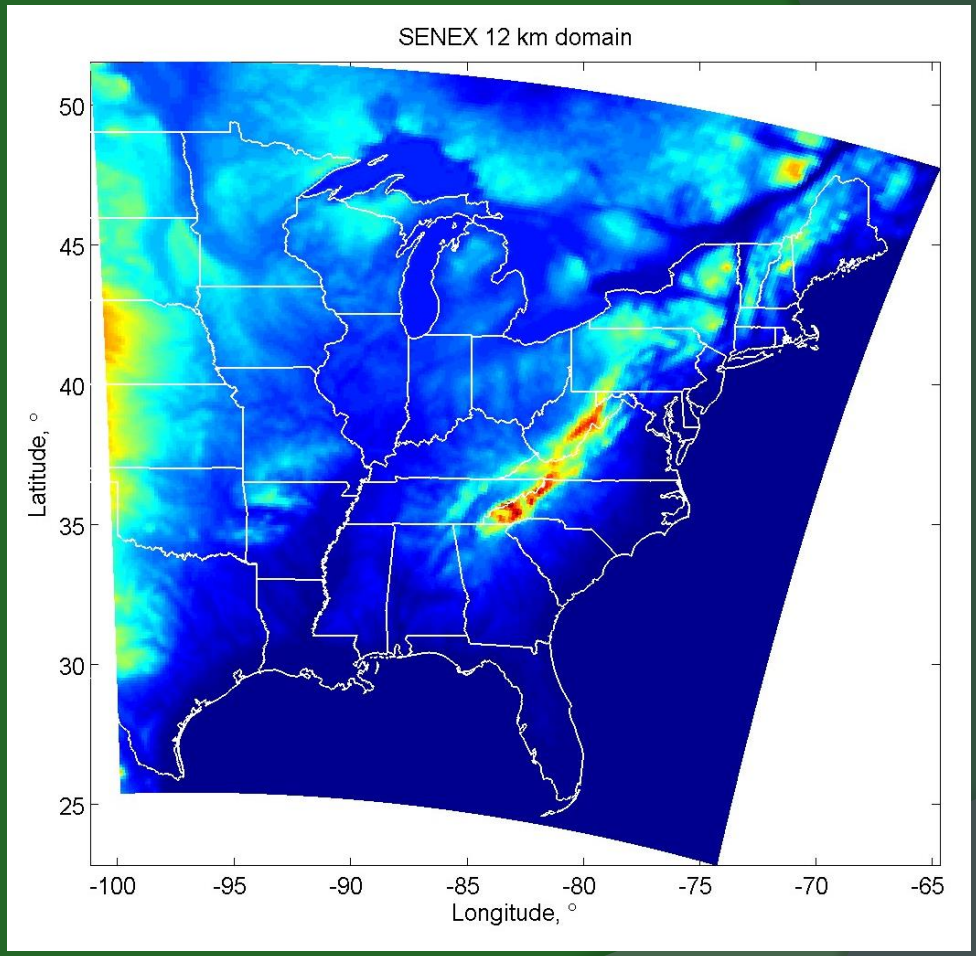
Scales

We run WRF on a 12-km grid that covers roughly the eastern half of the U.S. (terrain height plotted)

FLEXPART domain is slightly smaller.

To date we are using emissions only in this domain, nothing from larger scales.

WRF output is every half-hour, FLEXPART (forward) every hour, effective time resolution along flight tracks is of order a minute.



Existing products

FLEXPART was run forward in forecast mode with both GFS (global) and WRF driving during the campaign:
http://www.esrl.noaa.gov/csd/groups/csd4/forecasts/senex/

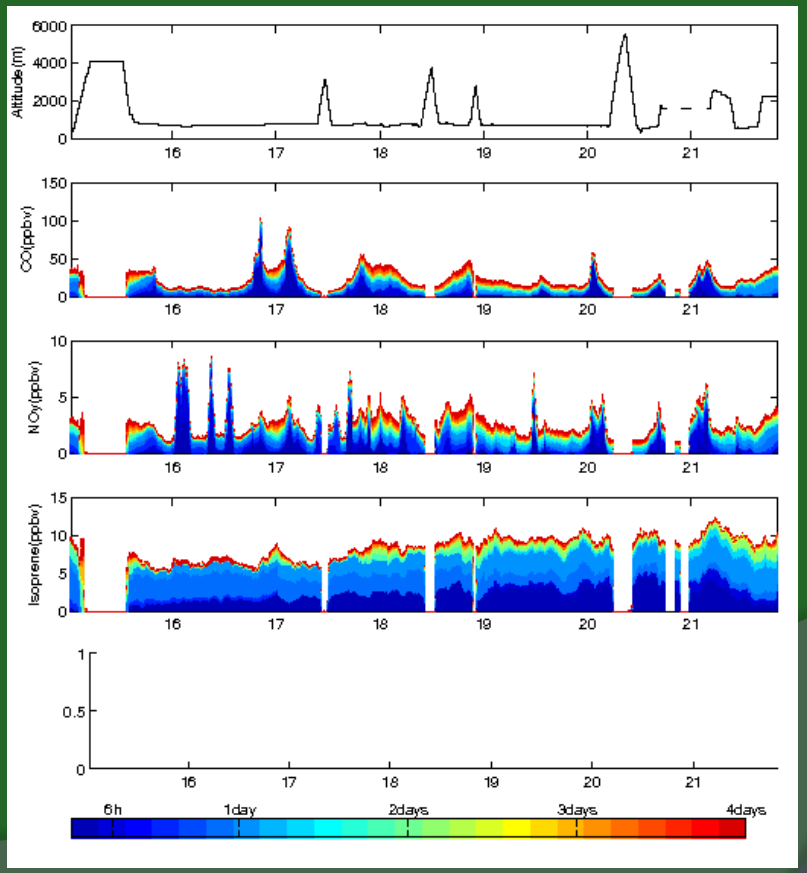
FLEXPART backward runs for P3 flights:
http://www.esrl.noaa.gov/csd/groups/csd4/forecasts/backward/

WRF ensemble runs for 27 May – 15 July
Six ensemble members
Contact Wayne Angevine

Backward products

Tracer time series and ageclasses of passive tracers over 10 days of transport:

Time series simulated by FLEXPART-WRF for the 06/22 flight



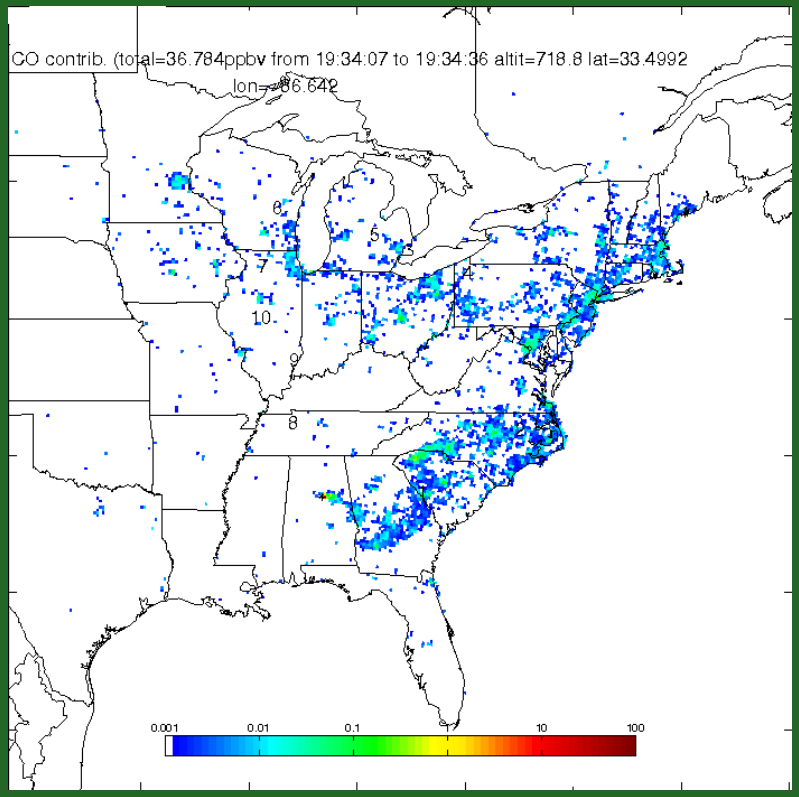
ASCII and IGOR binary files (credit: **Ken Aikin**) of:

- CO time series
- Noy time series
- SO2 time series
- Biomass burning CO time series
- Isoprene time series
- Monoterpene time series

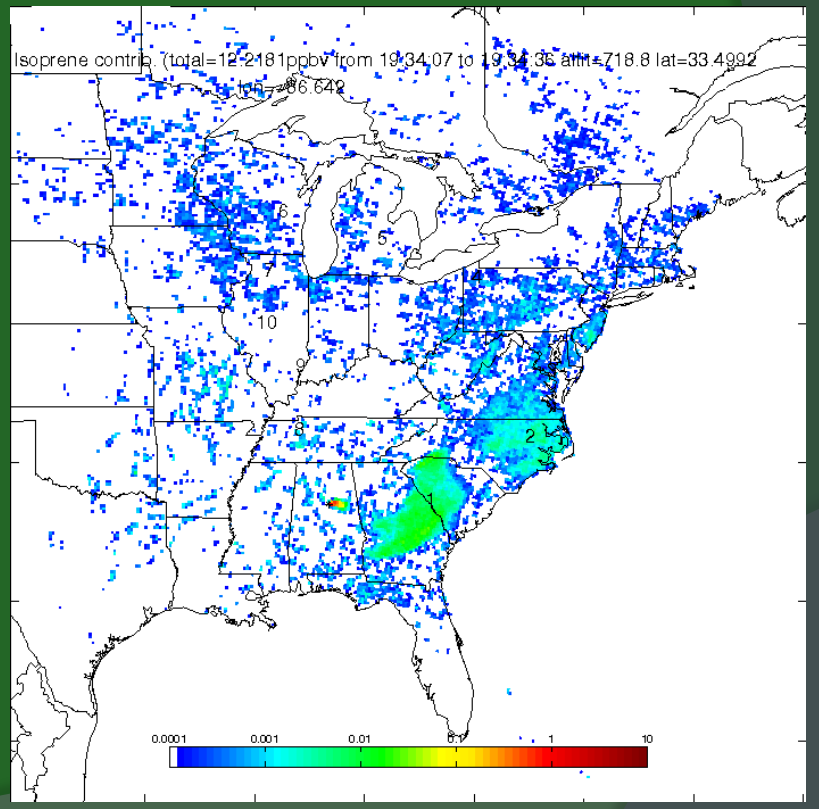
Backward products

Maps of footprints and surface contributions from different surface sources:

Example of Anthropogenic CO contribution for a plume on 06/22 19:34:07



Example of Biogenic isoprene contribution for a plume on 06/22 19:34:07



Planned products

Ensemble of forward FLEXPART runs for 28 May – 15 July using CO emissions

Our own science

Shallow cumulus

- importance to vertical mixing and transport
- how poorly represented in WRF?
- how to improve?
- couple improvements into FLEXPART

Soil moisture treatment

- importance
- how bad is it?
- can we do better?

Uncertainty of FLEXPART results

- No applicable literature on this vital question
- Attack with an ensemble approach

Nighttime, morning and evening transitions

Uncertainty and evaluation

Statistical evaluation of WRF is often unenlightening
Process studies are more helpful
Lagrangian results can contribute to WRF evaluation
Not possible to reliably identify one run as the “best”

Uncertainty of Lagrangian results is difficult to estimate

Our approach:
Build designed ensemble of WRF runs

- Six members
- Two PBL schemes, two initial datasets, two soil moisture treatments

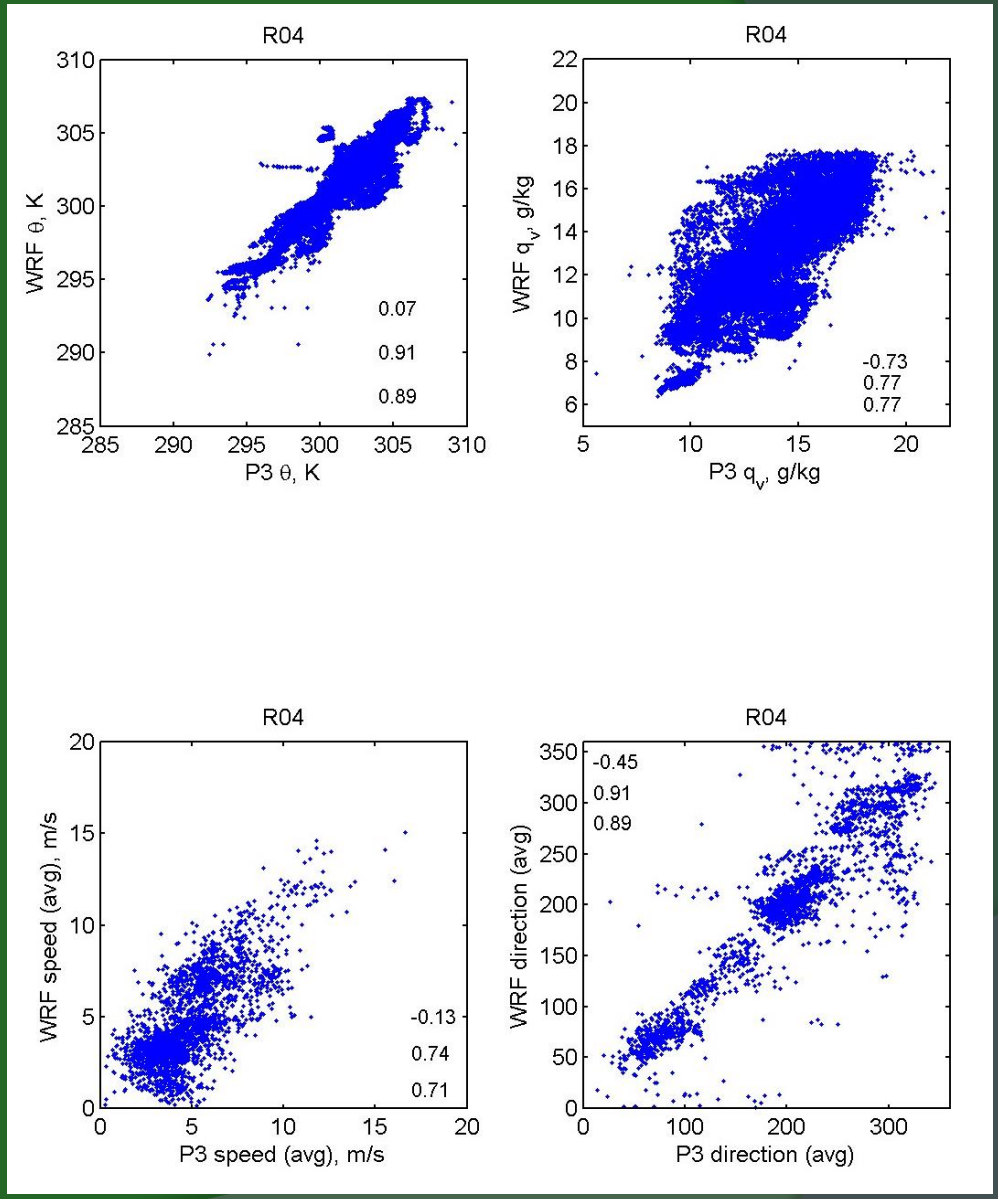
Run FLEXPART on each WRF output (no other changes)
Estimate transport uncertainty as ensemble spread of tracer mixing ratio

WRF statistics vs. P3

For one WRF ensemble member

Small biases, reasonable std. dev., good correlations

The other 5 members are statistically indistinguishable

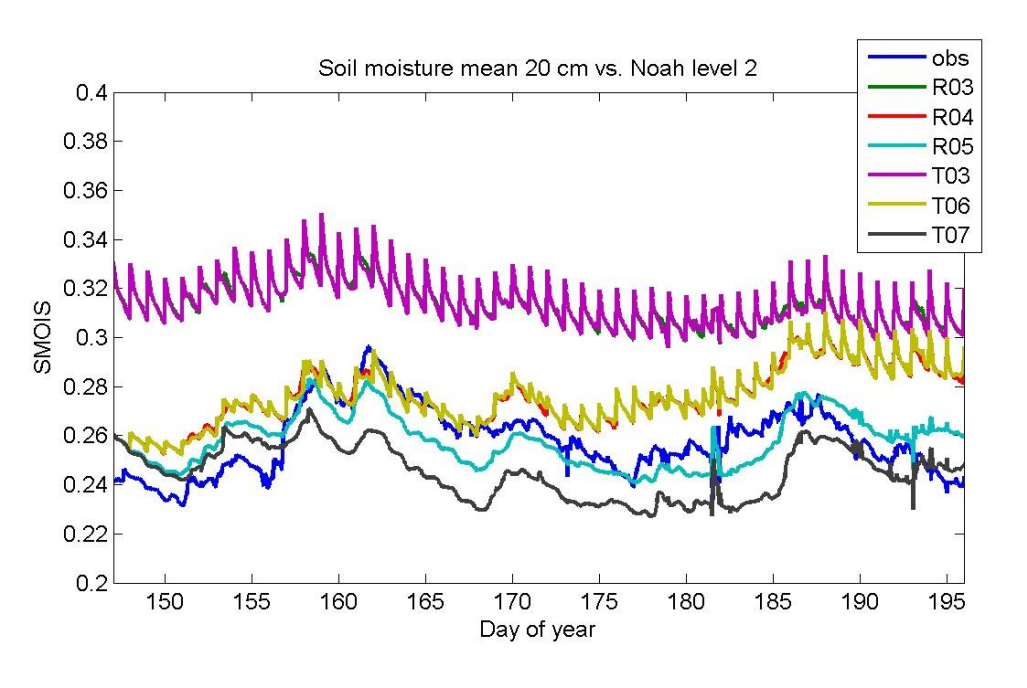


WRF soil moisture

At 28 Climate Reference Network sites

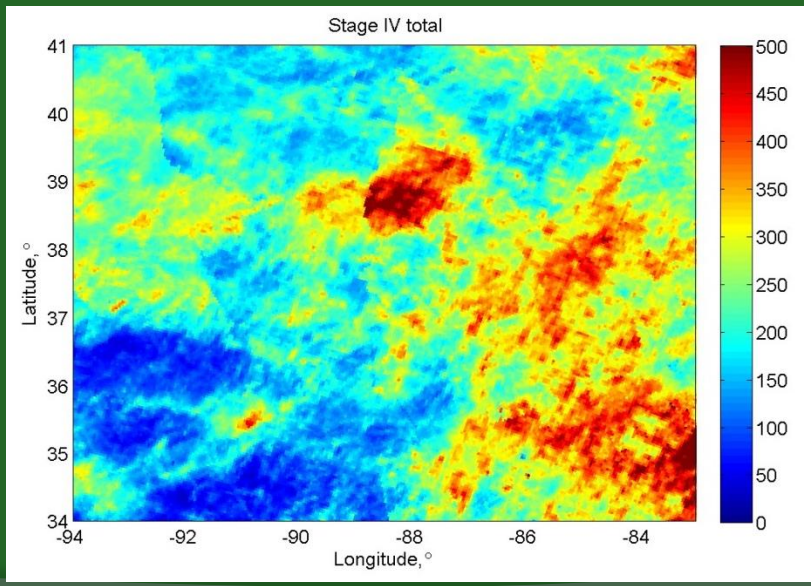
GFS soil is too moist and strong diurnal cycle is visible as WRF fights to dry down each day (R03 & T03)

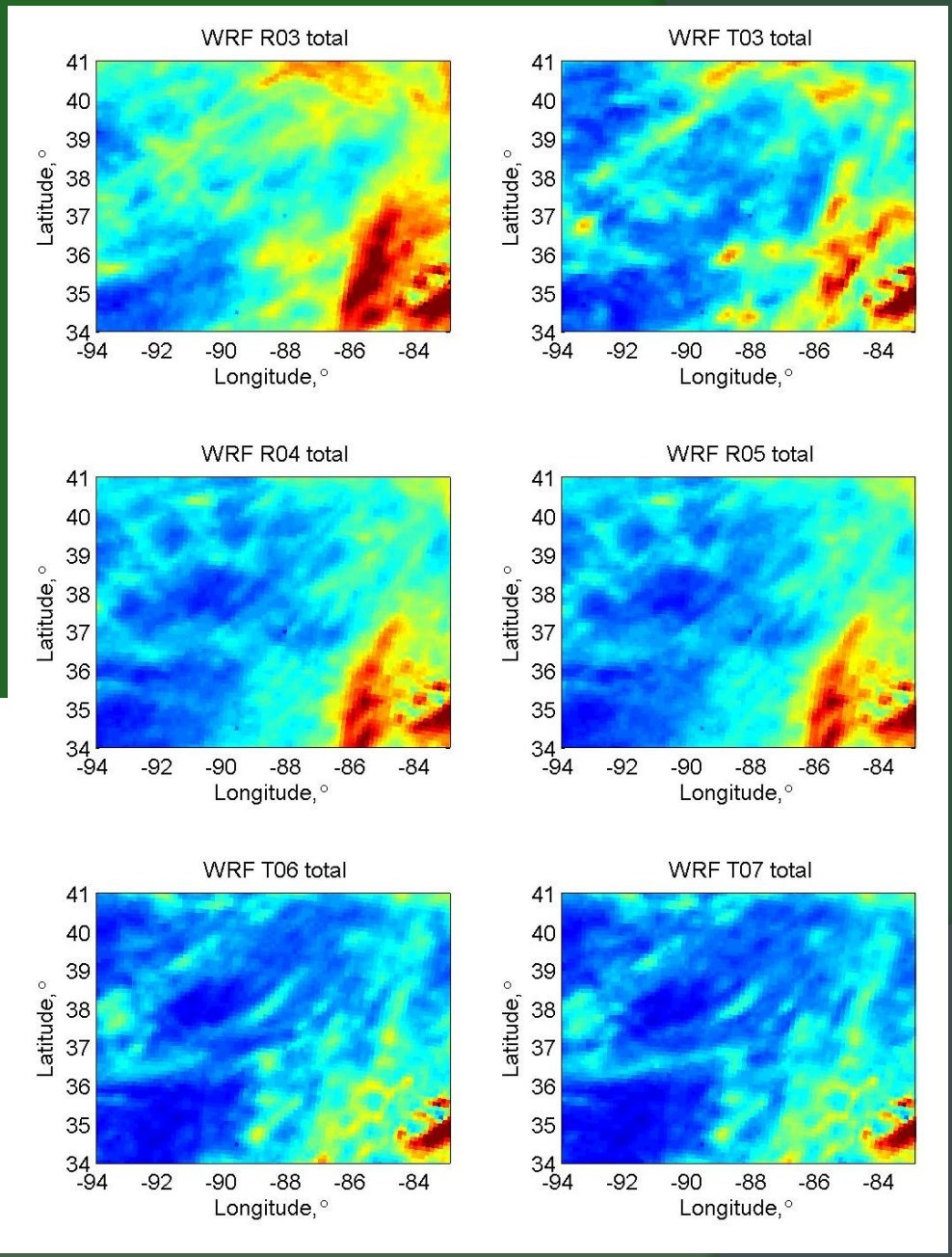
ERA-Interim soil is better even when used directly but continuous cycling improves result after mid-June



WRF precipitation

Total precip for 27 May – 15 July
Obs from Stage IV (blended radar and gauge product)
All WRF runs underestimate total except R03, T03 next best – both have too much soil moisture!
All runs miss heavy precip in north central domain in late June

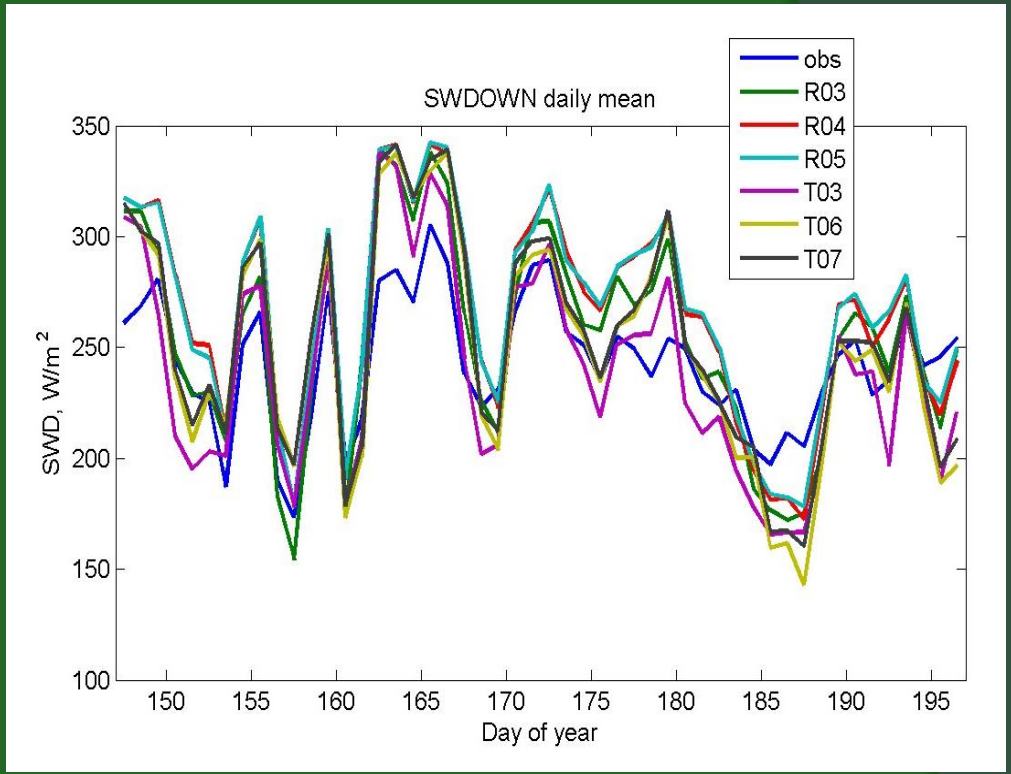




WRF insolation (SW down)

Daily mean (all hours)

TEMF PBL members (aware of shallow cloud) are closer to obs but with lots of day-to-day variation



FLEXPART ensemble spread (uncertainty)

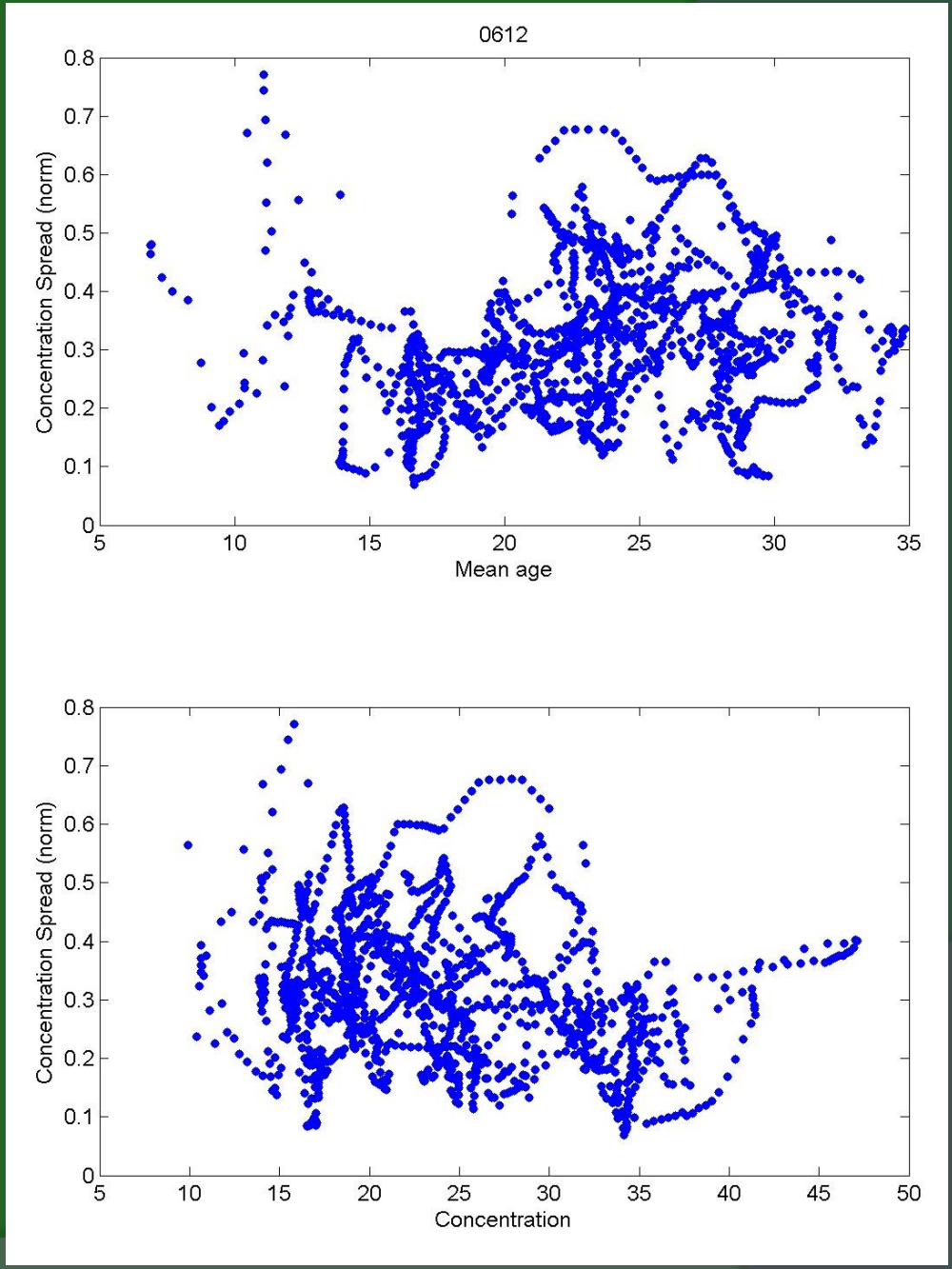
P3 flight of 12 June (Atlanta)

Spread is mixing ratio max-min, normalized to mean mixing ratio

Mean spread 32%

Some reduction at moderate ages and high mixing ratio

Very preliminary!



Recap

Backward FLEXPART runs are available
Six-member WRF ensemble is ready
Forward FLEXPART runs will follow shortly
Uncertainty analysis is ongoing
More WRF evaluation ditto

Contact me for custom products / analyses:
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