The Simulation of Doppler Wind Lidar Observations in Preparation for ESA's ADM-Aeolus Mission

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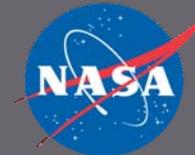
Quick Introduction to Doppler Wind Lidar

- The Doppler Wind Lidar Concept
  - Lidar backscatter is Doppler shifted by a scattering agent
  - Improved accuracy in height assignment
- Spaceborne Doppler Wind Lidar
  - Global, 3D measurements of wind
  - ESA **ADM-Aeolus** (late 2011)
    - single horizontal wind component
  - NASA **3D-Winds** (NRC Decadal Survey recommendation)
    - Full horizontal wind

Observation Count
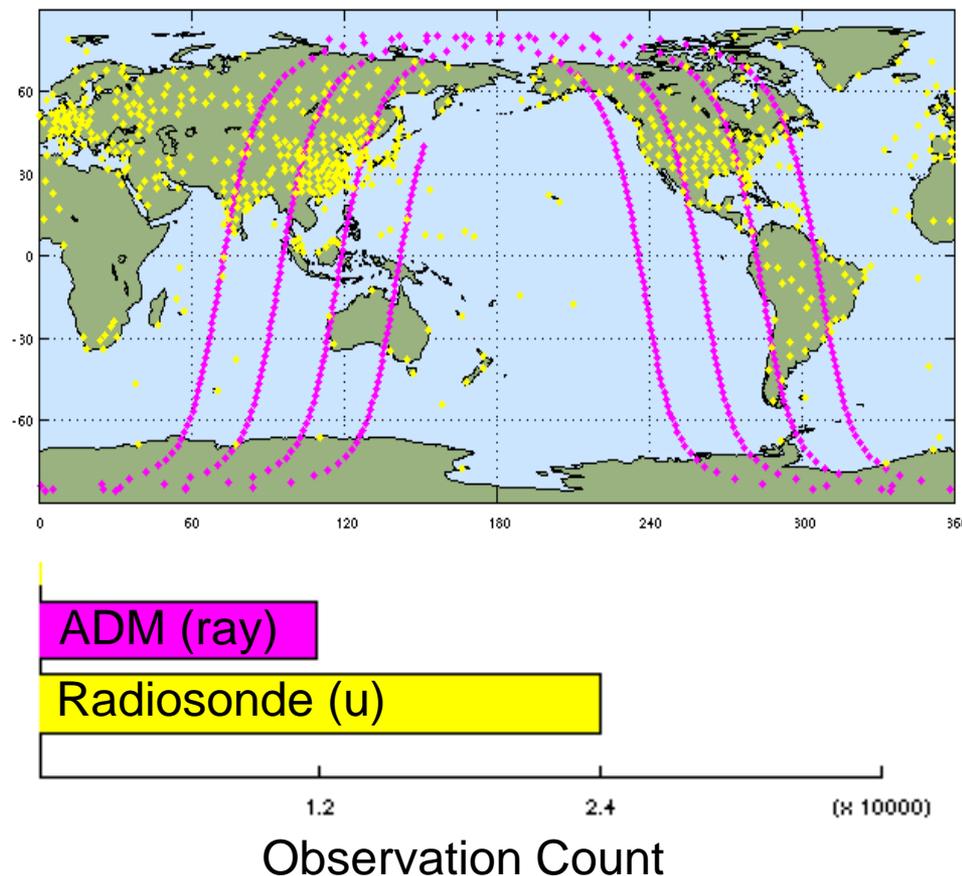
ADM-Aeolus Pre-Assimilation Data Flow Chart

- **Direct-Detection technique (355 nm)**
  - Vertical profiles in clear sky (Rayleigh)
  - Higher quality measurements in presence of scattering agent (Mie)
- **Orbit Characteristics**
  - 408 km, Dawn-dusk. Sun-synchronous
- **Viewing Geometry/Sampling**
  - 90° off-track (away from sun)
  - One 50 km profile every 200 km
- **Availability**
  - Data will be available in Near-Realtime

- ## Processing & Distribution

  - L1B distributed in NRT by ESA

  - L2B processing part of ECMWF integrated forecast system (IFS)

    - Unavailable to other operational systems (timeliness)

    - All major DA centers will have to run L2B processing independently

      - Software expected be made readily available (D. Tan, ECMWF)

    - Potential external L2B processing in near-realtime by EUMETSAT (A. Stoffelen, KNMI)
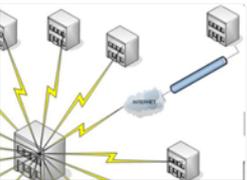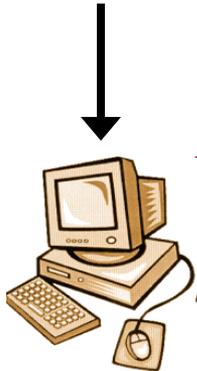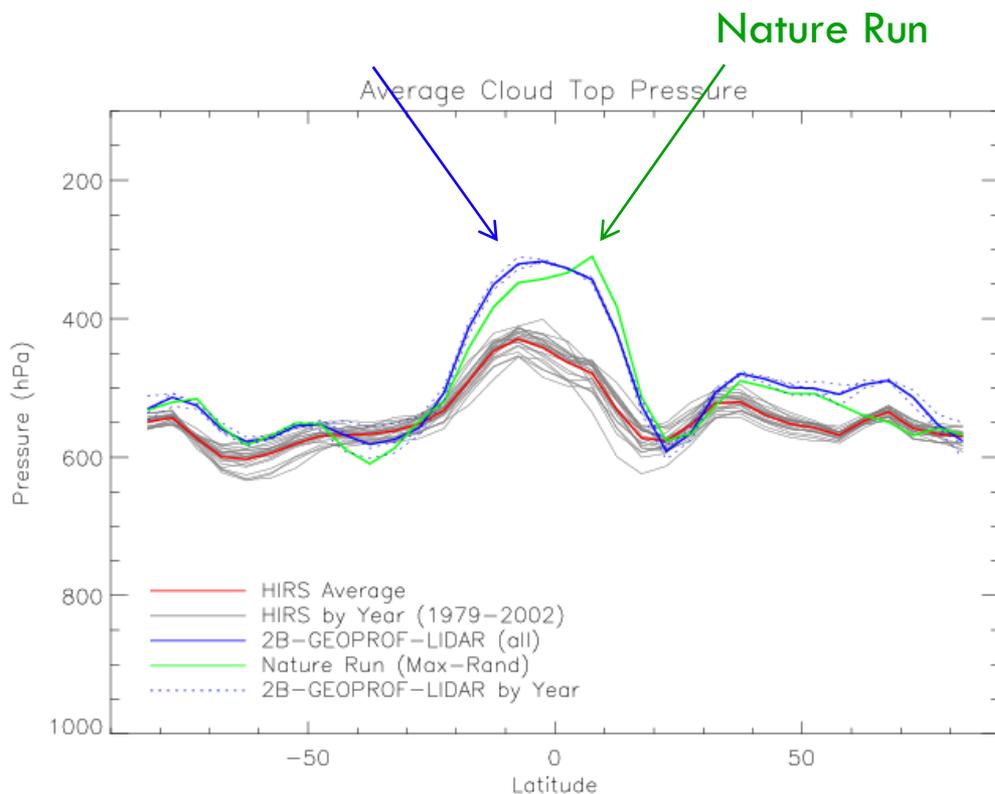
- Realistic Proxy Data - No spaceborne heritage, must simulate observations

- Utilize OSSE framework
  - Joint OSSE Nature Run (ECMWF, T511)
  - Existing observing system developed in-house at GMAO (R. Errico & R. Yang)
    - conventional and remotely-sensed observations
  - Simulate ADM observations
    - Lidar Performance Analysis Simulator (LIPAS), via KNMI (G.-J. Marseille & A. Stoffelen)
    - Need proper sampling (spatial & vertical), yield, and error characteristics
  - Not intended to sell ADM (already sold)

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Clouds in the Joint OSSE Nature Run

CALIPSO/ CloudSat L2
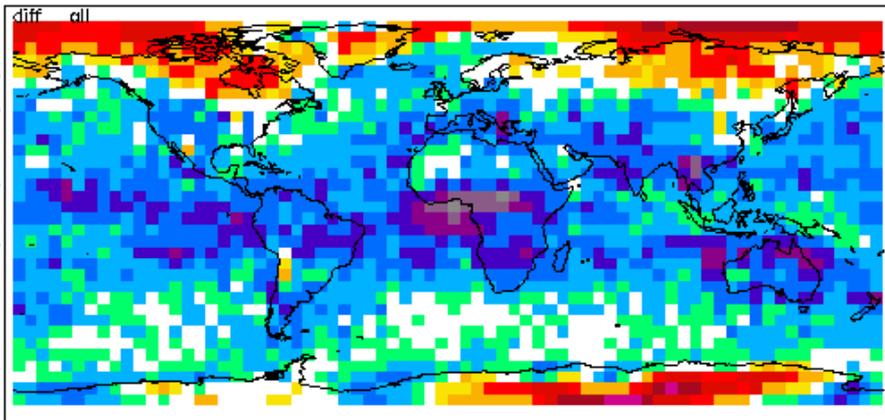

Nature Run

- **Importance of clouds**
  - The top of a cloud can act as a scattering agent
  - Optically thick clouds limit wind retrievals

- **Placement of clouds**
  - Realistic vertical placement of clouds
  - NR underestimates cloud amount
    - ~12% globally
    - Related to measurement yield
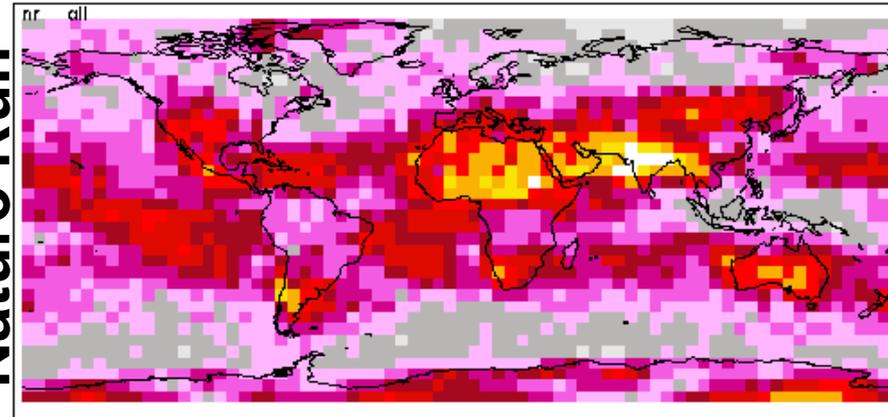
Clouds in the Joint OSSE Nature Run

- Cloud Fraction for all cloud tops
  - NR lacks clouds
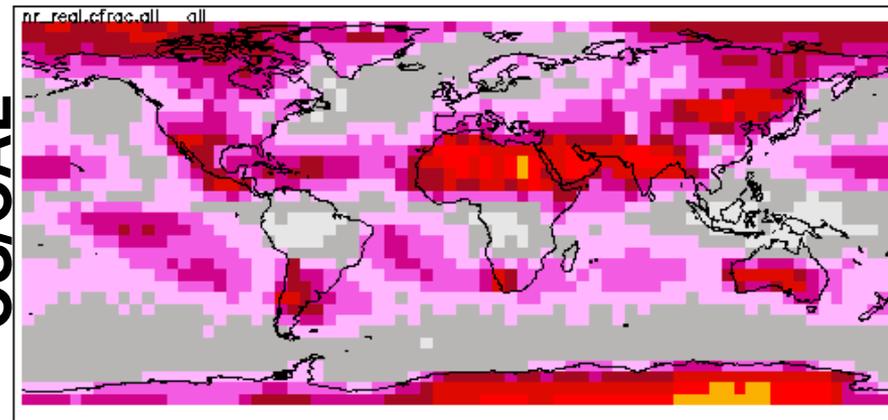- Too few clouds, too many observations

Nature Run

Difference

CS/CAL

−1.00 −0.75 −0.50 −0.25   0.00   0.25   0.50   0.75   1.00

Aerosols in the Joint OSSE Nature Run

- Like clouds, aerosols act as both scattering and extinction agents

- Placement

  - Not available in the NR

  - Traditionally taken from a climatological background

    - Inconsistent with atmospheric state

  - Dynamically-consistent aerosol fields

    - GOCART aerosol transport model embedded in the GEOS-5 model

      - Aerosol fields forced by the meteorology of the Nature Run

Simulated DWL Observations from ADM

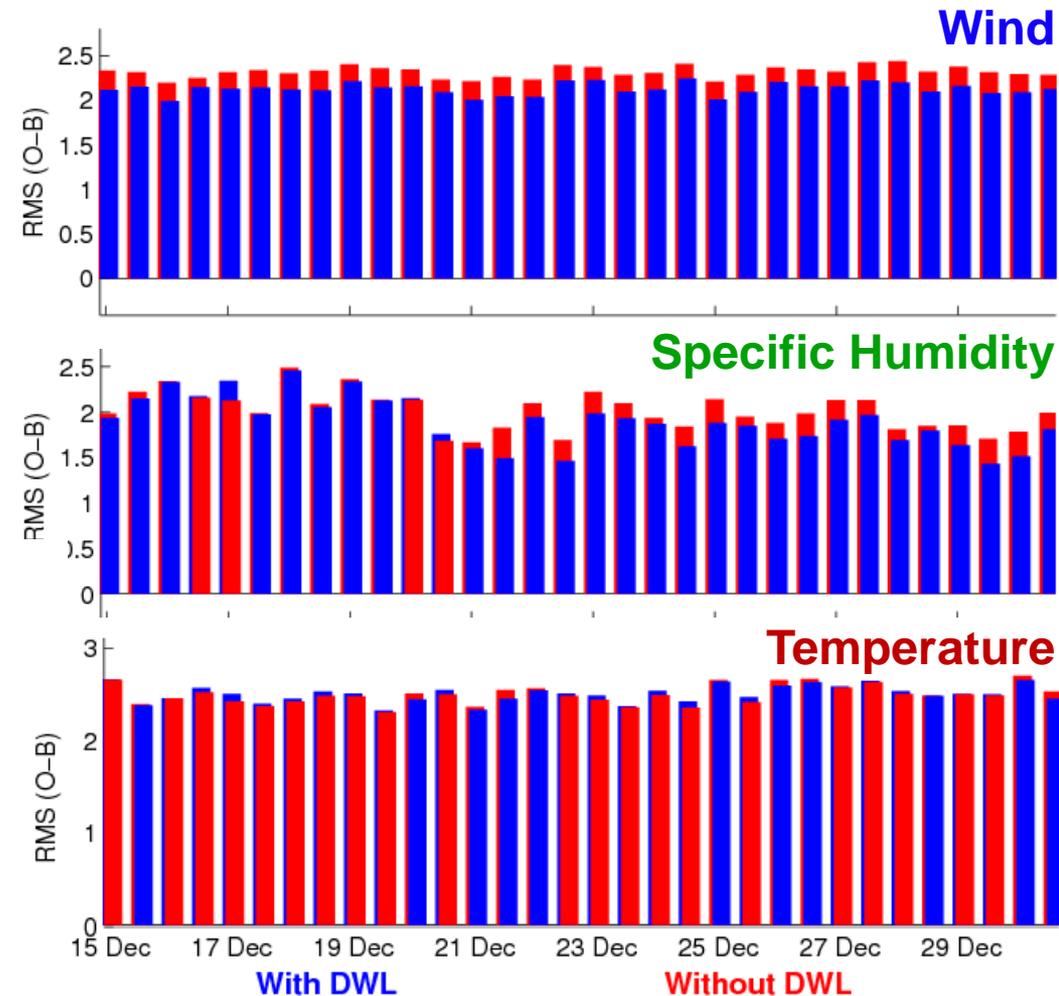- **Rayleigh Channel observation errors from ADM**
  - NR-Simulated
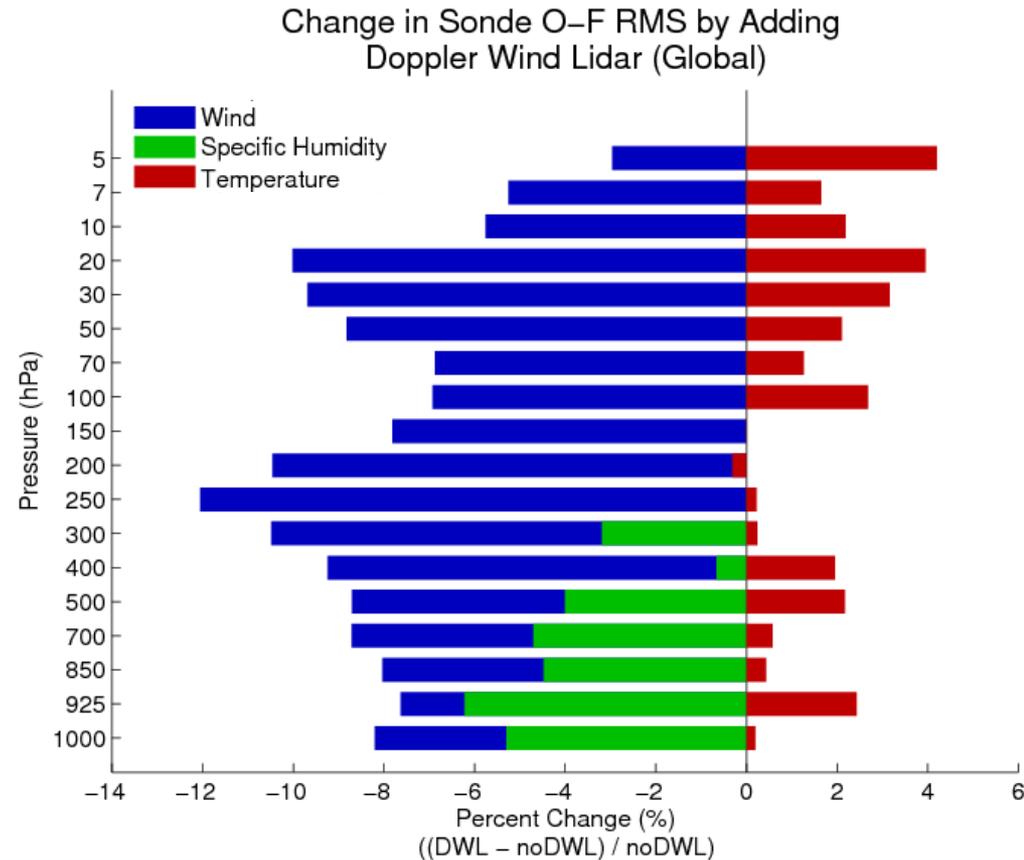 - Not burst-mode
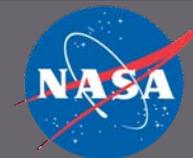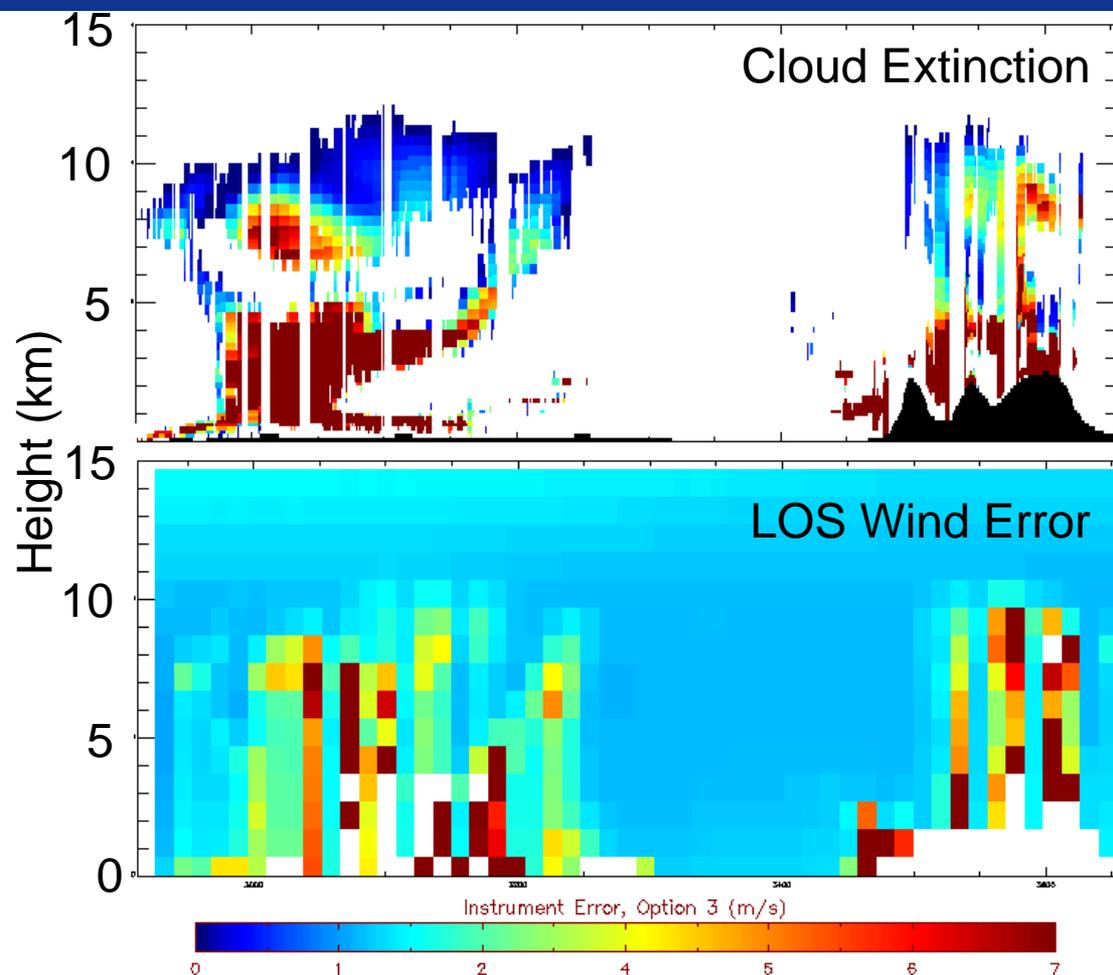
Assimilation of Simulated ADM Measurements

- Initial cycling studies have been performed
  - Two weeks
  - Not entirely spun-up

- Blue on top, DWL reducing O-F RMS

- Red on top, DWL increasing O-F RMS

Wind

Specific Humidity

Temperature

With DWL   Without DWL

Assimilation of Simulated ADM Measurements

- # Wind RMS reduced throughout vertical
  - ## Simulated ADM observations measure to 30 km
- # Largest changes in T RMS seen in stratosphere
  - ## Fewer observations
- # Overall q_v RMS impact dominated by mid & lower tropospheric signal

Change in Sonde O–F RMS by Adding Doppler Wind Lidar (Global)

Legend:
- Wind
- Specific Humidity
- Temperature

Pressure (hPa): 5, 7, 10, 20, 30, 50, 70, 100, 150, 200, 250, 300, 400, 500, 700, 850, 925, 1000

Percent Change (%) ((DWL – noDWL) / noDWL)

Ongoing and Future Efforts

- NR cloud verification manuscript (in progress)

- Aerosol verification (in progress)

- NR cloud tuning (future)

- ADM simulation (first version complete)
  - Existing DA infrastructure show mechanics seem correct
  - Deficiencies in simulated ADM measurements known (too few clouds, no added representativeness error, etc.)

- DA studies (ongoing)
  - Full observation system development (first version complete, R. Errico & R. Yang)
  - Refine DA methodologies for ADM, (QC and error handling, in progress)
  - Investigate forecast impact and observation sensitivity studies