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Global Assimilation of Loon Stratospheric Balloon Observations

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GMAO
Global Modeling & Assimilation Office

Poster Number 1542

The Problem

Verification of global data assimilation system (DAS) output fields by independent observations insures the quality of these products for scientific studies and can highlight the need for additional observations to improve the quality. This is especially important for middle atmosphere winds where there are few "in situ" observations available to constrain the DAS. Here we use constant pressure balloon derived winds to evaluate the lower stratospheric winds in the NASA GEOS DAS.

Loon Balloons

https://loon.co/

Goal: launch and maintain a fleet of balloons to provide Internet coverage to users on the ground.
Status: over 25 million km of test flights since the project began.
Flight Duration: up to 190 days in the stratosphere.
Winds: Derived from Loon Balloon GPS determined locations.

Methodology

NASA GMAO MERRA-2 Data Assimilation System

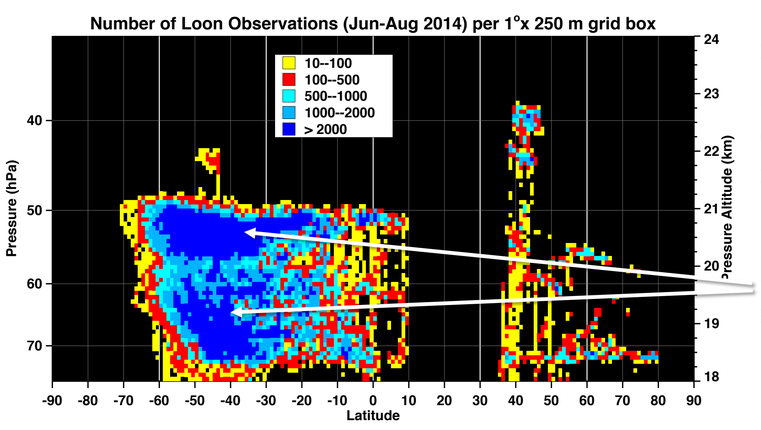
Two Experiments:

1. Control Experiment (assimilation of standard observation set)

2. Loon Experiment (assimilation of Loon balloon derived winds + standard observation set)

Test Time Period: June-August 2014 (large number of Southern Hemisphere Loon Balloons)

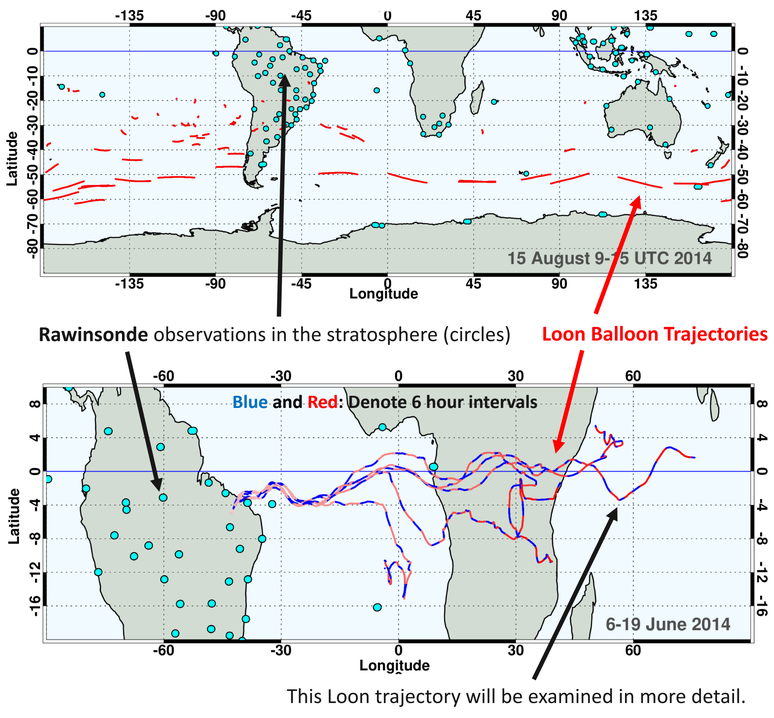
Loon Balloon Distribution (June-August 2014)



Southern Hemisphere
Loon Balloons 70-50 hPa (18-21 Km) Altitude
60°S to 10°N Latitude

Balloon Altitudes are adjusted while in flight

Examples of Loon Balloon Coverage



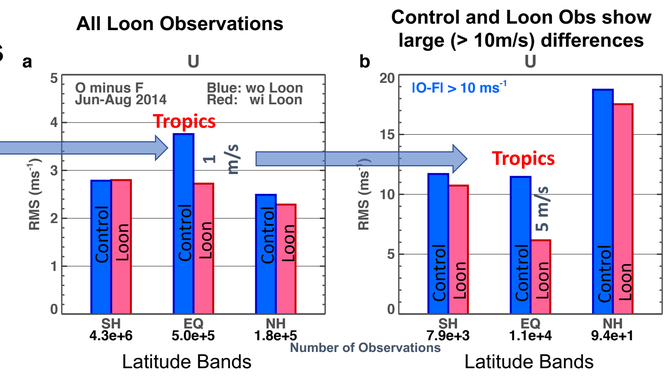
6-Hour Assimilation System Data Window
Loon balloons can fill in wind observations over the oceans.

14 Days Tropical Coverage
Tropical observations provided some of the largest DAS adjustments when assimilating the Loon winds.

Forecast Improvement (o-f) RMS Summary

Assimilated Loon Balloon Winds greatly improves the tropical background forecast

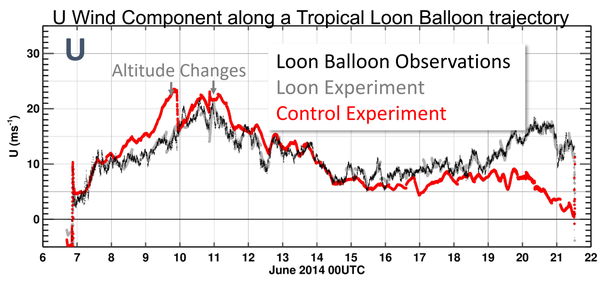
Note: o-f denotes the difference between the observation and the short background forecast



Analysis Improvement (o-a) RMS Example

Analysis winds interpolated by the DAS in space and time to the Loon position

Note: o-a denotes the difference between the observation and the DAS analysis

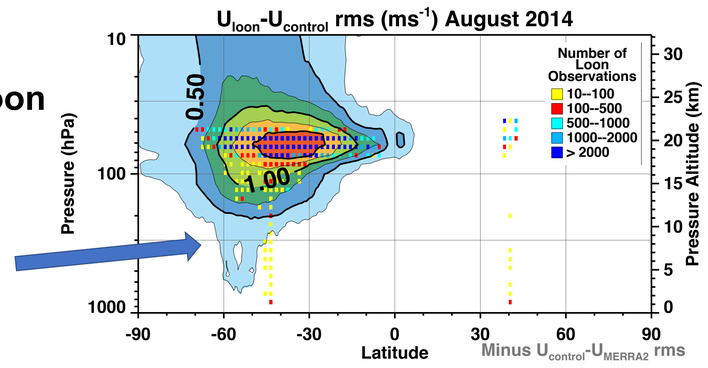


Large differences occur between the **Control Experiment Analysis** and **Loon Observations** that are corrected in the **Loon Experiment Analysis. (Black and gray are on top of each other.)**

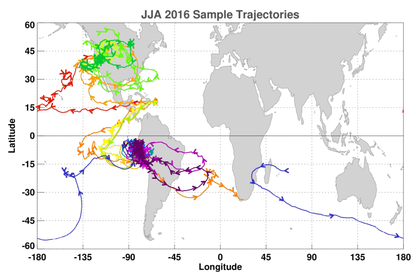
Analysis Differences (RMS) August 2014

Control and Loon Balloon differences found mainly at Loon Balloon Altitudes

Evidence of some influence extending into the troposphere, below the Loon Balloon altitude.

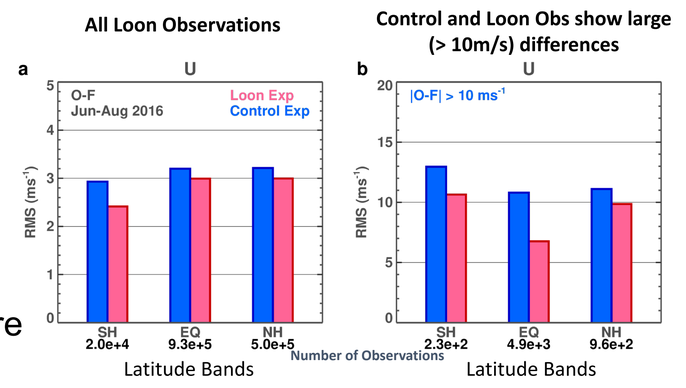


Additional Test Time Period (June-August 2016)



Sample Trajectories (~100-70 hPa Altitude Range)
Western Hemisphere Concentration

Confirmation of 2014 Results
O-F RMS
Improvements at all latitudes, more significant improvement in tropics



Conclusions

1. **Additional wind observations can improve data assimilation products in the lower stratosphere, especially in the tropics**
2. **Current tropical wind analyses in the lower stratosphere can have errors larger than 10 ms^{-1}**
3. **Some of the stratospheric wind analysis improvement may be accompanied by improvements in the upper troposphere wind analysis (further investigation is planned)**

Coy, L, M. R. Schoeberl, S. Pawson, S. Candido, & R. Carver, 2018, Global assimilation of X Project Loon stratospheric balloon observations, Submitted to *J. Geophys. Res.*

GMAO Publication List

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