A33Q-2934 - Global Assimilation of Loon Stratospheric Balloon Observations and their Trajectories Relative to Tropical Waves

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GMAO
Global Modeling & Assimilation Office

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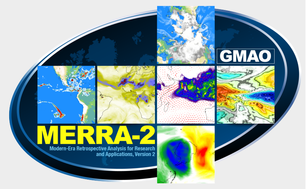
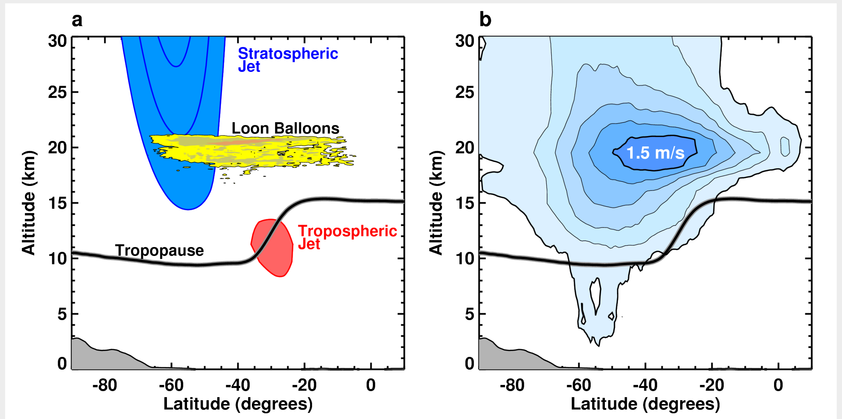
LOON BALLOONS: Data Assimilation

- Loon is a network of stratospheric balloons, designed to extend Internet connectivity to remote areas.
- Loons can adjust altitude in flight to control their trajectories based on vertical wind shear.

NASA Global Modeling and Assimilation Office Data Assimilation System

- Data assimilation combines a global forecast model with observations to produce a global meteorological analysis
- **Control:** no loons assimilated
- **Loon:** loons included in assimilation





a) The density of Loon balloon observations during August 2014 (yellow shading) and b) root mean squared zonal wind changes in the GMAO data assimilation system (DAS) during August 2014 produced by including the Loon balloons into the DAS. The contour interval is 0.25 m/s.

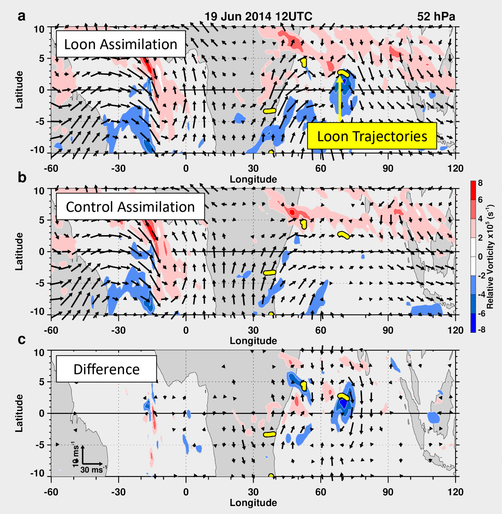
Coy et al. (2019) assimilated three months (June-August 2014) of the Loon balloon winds into the NASA GEOS global data assimilation system (DAS). Several Loons were also in the tropics during June.

Coy, L., M.R. Schoeberl, S. Pawson, S. Candido, and R.W. Carver, 2019: Global assimilation of Loon stratospheric balloon observations. J. Geophys. Res.: Atmos, 124. https://doi.org/10.1029/2018JD029673

RESULTS:

Assimilation of Loon balloon trajectories can improve global analyses, especially in the tropics where they can characterize equatorial wave motions.
The Rossby wave vertical shear of meridional and zonal wind can be used to influence Loon trajectories.

Example: Loon Assimilation



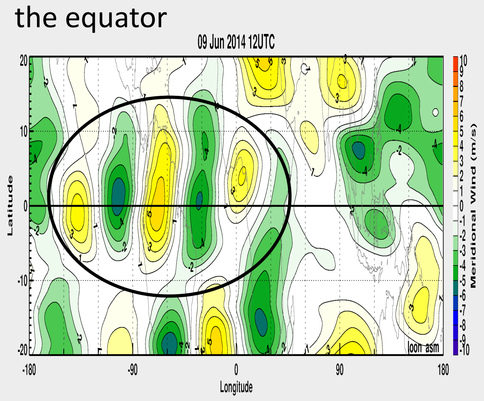
a) Loon Assimilation, b) Control Assimilation, and c) Difference

Wind vectors show wave patterns across the tropics.

Loon assimilation increases the wave amplitude

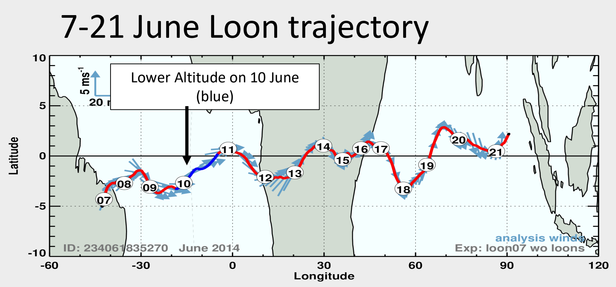
Example: Wave Structure

Wave train trapped within ~10° of the equator

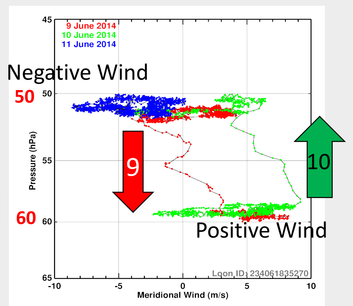


Meridional wind (m/s) from the Loon assimilation filtered for zonal winds 1-6

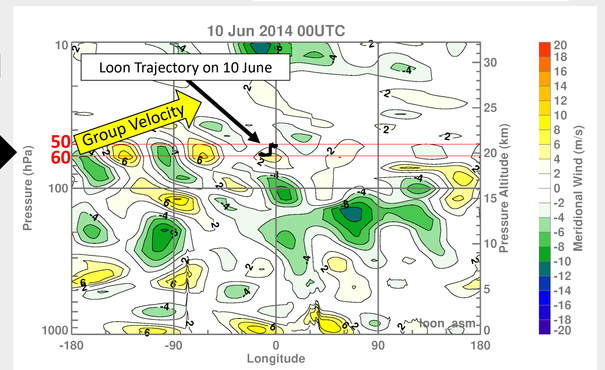
Case Study: Loon balloons and vertical wind shear



Loon descends on the 9th and ascends on the 10th experiencing different meridional winds.



- Equatorial cross section showing vertically propagating waves associated with the wind shear changes seen by the Loon balloon.
- Adjusting Loon altitudes in the wave's vertical shear provides a mechanism for keeping near the equator.
- Future NASA plans call for increased vertical resolution in the stratosphere enabling better analysis of these equatorial waves.



BACKGROUND: Equatorial Waves

- Large-scale, equatorially confined waves
- Propagate vertically and zonally
- Periods of a few days
- Planetary scale in zonal direction
- Trapped within ~10° of the equator
- Rossby Waves have Nonzero Equatorial Meridional Wind

Phase and Group Velocities

(Upward Propagating Rossby Waves)

- Phase Velocity: to the West
- Group Velocity: to the East

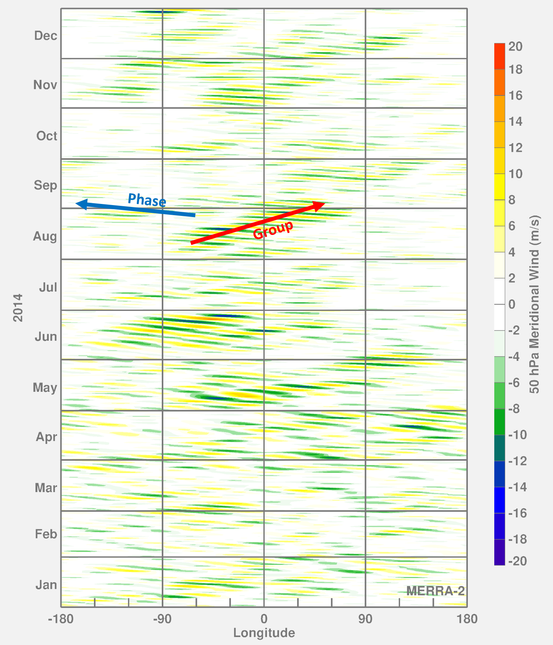
Meridional equatorial winds for 2014 at 50 hPa.

The phase and group velocities are apparent in wave packets throughout the year.

The phase velocity is approximately double the group velocity, ~10 and 5 m/s respectively in this example.

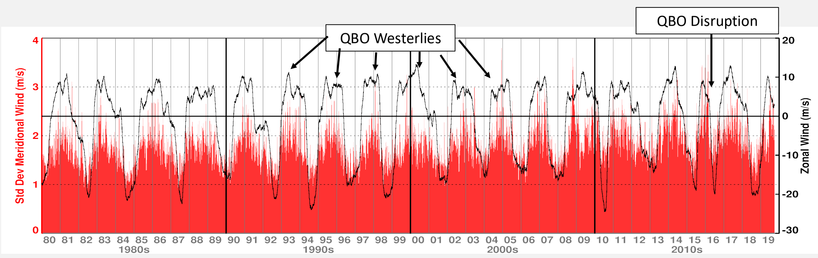
Merra-2 meridional wind averaged 10°S-10°N and filtered for zonal waves 1-6.

Note strong waves during June 2014.



Equatorial Wave Climatology

The Quasi-Biennial Oscillation (QBO) in the east-west equatorial wind direction controls the vertical propagation of equatorial Rossby waves with strong wave activity associated with westerly winds.



The standard deviation about the equator of the meridional wind component (red shading) and the zonal mean zonal wind (black curve), both at 50 hPa. MERRA-2 winds averaged from 10°S to 10°N.

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