GEOMETRIC CLOUD MOTION WINDS IN A CONVOY OF SATELLITES

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Abstract
To date, mesoscale winds are not well exploited in global NWP and climate models and the dynamical phenomena of turbulence and moist convection are not fully explicitly represented in these models, while increasingly responsible for the loss of life and property.

The geometric Clouds Motion Winds (gCMW) tandem-satellite concept targets the measurement of height-resolved wind fields exploiting the effect of parallax, first elaborated from space by NASA MISR. A multi-angle imaging spectrom-radiometer is targeted for providing cloud top heights and height-resolved wind components, vertical motion, aerosol and cloud structures using a multi-angle imager and geometrically enhanced. Improved performance with respect to earlier flown missions may be achieved by:
1. Launching a tandem of gCMW satellites, e.g., one leading and one following MetOp or S3, providing improved wind and height,
2. Allowing night-time and high-level measurements by using infrared channels,
3. Increased computer power for high-resolution NRT processing and
4. Obtaining winds at several heights by using different visible and near-infrared frequency channels showing atmospheric structure.

This information would greatly complement the MetOp and S3 observation capability and thus degrade its accuracy.

In case of tandem satellites, a first view of the satellite may be collocated in time with a fore view of the second satellite. Cloud dynamics and motion then play no role in determining the geometric height of the clouds from the combined fore and aft images. Subsequently, additional views at different times and angles help close the problem of obtaining both dynamical and height information from the associated images.

As such, there are a few reasons for tandem convoy satellites:
• Cloud dynamics, clouds evolve substantially on the 5-minute time scale and this affects the quality of gCMW; two satellites allow view time cycle for for cloud (forcast) and increased view time separation by satellite time difference:
• A tandem arrangement ensures that we do not get confusion between vertical cloud top height and horizontal motion;
• Two satellites provide a larger time base and thus more accurate information to vertically resolve cloud dynamical structures.
• Multiple zimuth perspectives; it may be technically easier to use multiviews for cloud structure.

Notes/Technique
In case of tandem satellites, an aft view of the first satellite may be collocated in time with a fore view of the second satellite. Cloud dynamics and motion then play no role in determining the geometric height of the clouds from the combined fore and aft images. Subsequently, additional views at different times and angles help to close the problem of obtaining both dynamical and height information from the associated images.

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References and further information
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Introduction
The idea of using satellite constellations and formations as a way to accomplish complex Earth Observation (EO) scientific objectives by exploiting synergies between different missions is not new and the success of these missions has further increased the interest within ESA and the wider European EO community for further applications of this concept [1].

The MetOp and MetOp Second Generation series of polar-orbiting meteorological satellites operated by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) are planned to provide long-term, continuous EO data streams in the post-GEO timeframe and provides an ideal mission operation context for an ‘Atmosphere’ convoy proposal as elaborated by ESA. Moreover, the MetOp orbits are close to the S1 and S3 orbits.

For the meteorology theme, the gCMW concept has been selected by ESA for further assessment and both the ‘Atmosphere’ meteorology theme and the selected concept are addressed in this paper.

Tandem satellites
The idea of using tandem satellite is in the fact that for a single satellite concept, such as MISR, view is taken at a different time. In cases of moderate or strong updrafts (1 m/s), the time difference between the first and last view may be a few 100 s, thus compromising an accurate height assignment. The parallax error due to height error projects on the along-track wind component and therefore degrades its accuracy.

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Conclusions
To investigate the potential that spacecraft constellations and formations present for Earth Observation, three ESA “Earth Observation Sentinel Convoys” studies have been conducted as part of the Earth Observation Support to Science Element (STSE) of the Earth Observation Envelope Programme (EOEP) of the European Space Agency (ESA). The tandem-satellite gCMW concept has been identified to provide accurate height-resolved day-and-night mesoscale 3D winds vectors near cloud tops. After a technical feasibility assessment, several of its characteristics may be further optimised for measuring, e.g., convective-scale clouds.

This idea of tandem gCMW satellites in convoy with MetOp or S3 is now further elaborated in an Earth Explorer 9 proposal, which is being written by a consortium of partners. The concept has also been elaborated in NASA’s C3 Winds plan [5].

Parameter Specification Comment
Configuration Lead-follower Nadir and/or AC view (match 4 min)
Master Satellite MetOp-SG / S3 Nadir time reference
Type of formation Leader-follower Centered around EPS-SG / S3
Number of platforms 1 + 2 (G) tandem for unique/accurate height and motion
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Satellite option 1 0.1 km resolution sufficient
Sensor gCMW See MISR and EER MSR (WINDS)
Wavelength/ frequency 380-900 nm Day and night coverage, more heights
Polarisation Off Global cloud polarization effects
Control cloud polarization effects
Smash 1500 nm goal
Incidence angle ±50° and 0° To obtain accurate geometric heights
Resolution 200x200 km (G) to obtain accurate geometric heights
Spatial resolution 1 km (G) to obtain accurate geometric heights
Vertical resolution 500 m
EOV < 5 mK Resolution preferred above low noise

Summary of the primary mission objectives for the gCMW convoy in formation with MetOp-SG

Table 1: The idea of using tandem satellite is in the fact that for a single satellite concept, such as MISR, view is taken at a different time. In cases of moderate or strong updrafts (1 m/s), the time difference between the first and last view may be a few 100 s, thus compromising an accurate height assignment. The parallax error due to height error projects on the along-track wind component and therefore degrades its accuracy.

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