3D measurement of Martian dune migration

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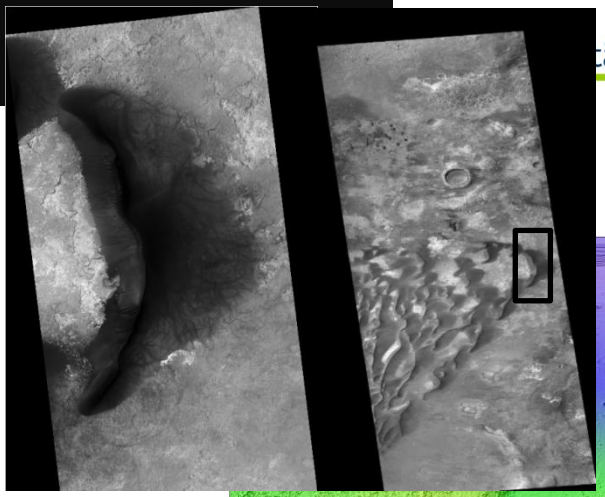
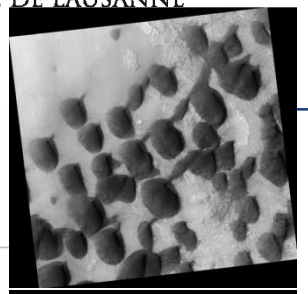
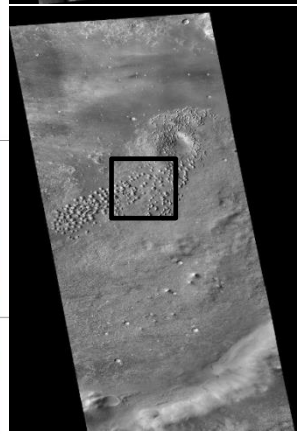
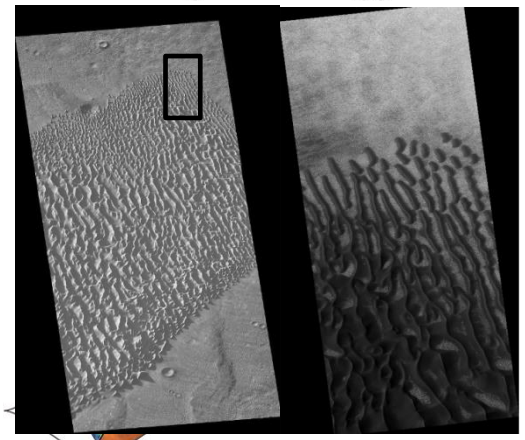
Background & test areas









- **Reliability of manual/automated measurements over textureless topography**
- **Target image resolution and the feasibility of sub-pixel accuracy measurement**
- **Temporal lags between the image acquisitions and the surface migrations**
- **Radiometric changes of target surfaces**

•Based on previous studies and the availability of CTX and HRSC overlapping coverage, the target areas and images are chosen as
(1) Kaiser crater : active bedforms, dune and gullies noted by HiRISE imagery. The best HiRISE time series for the dune migration measurements.
(2) Proctor crater : Partially active, wind regime consisting of three opposing winds (Fenton et al. 2005).
(3) Wirtz crater (48.6S, 334.74E)

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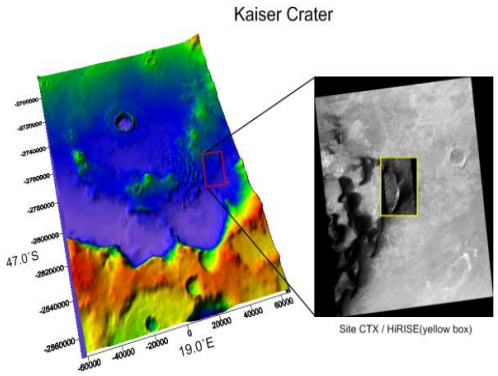
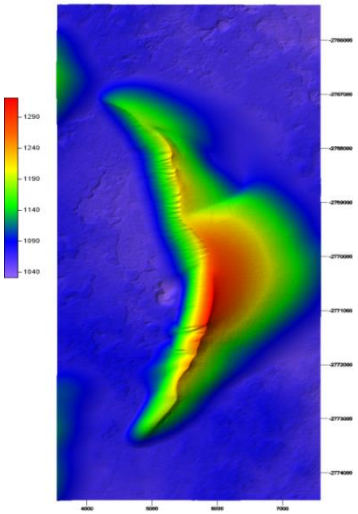
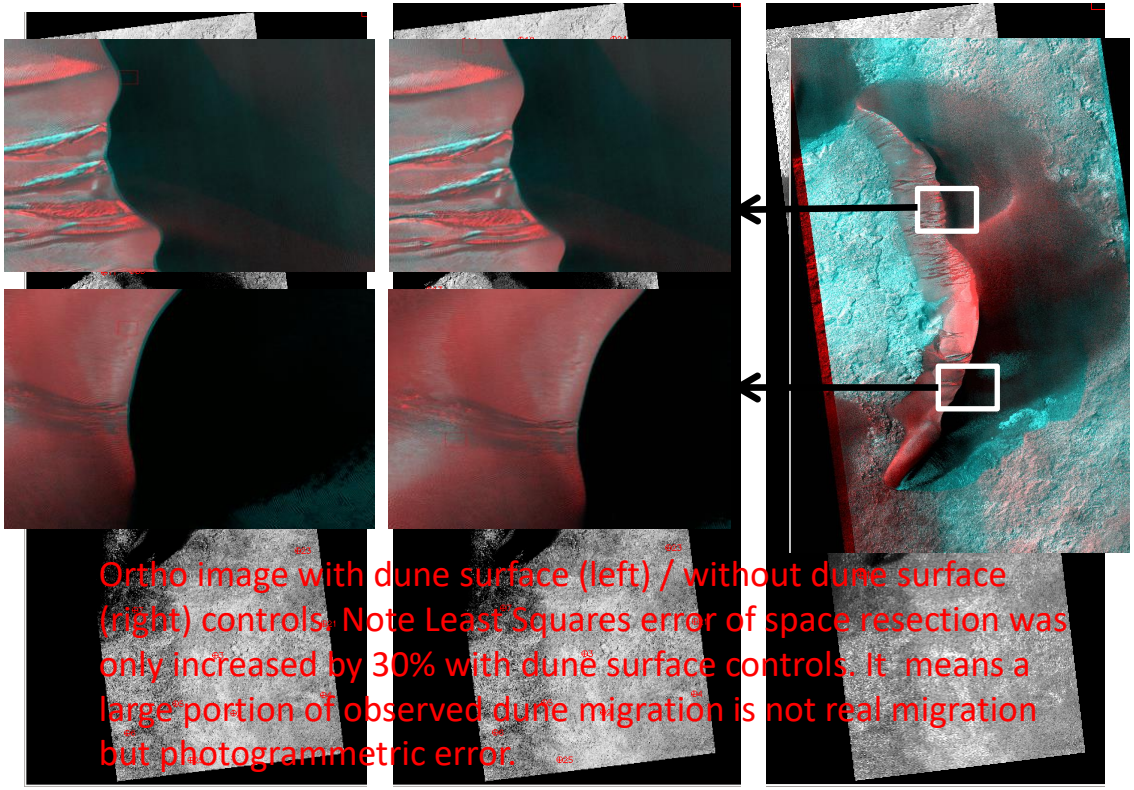
Photogrammetric control strategy

- Application of non-rigorous sensor model and 2nd ortho image generation
- Ground control using HIRISE stereo DTM







Control point setting with dune surface (left), without dune surface (mid) & check points

DTEED_016907_1330_016973_1330 by UoA

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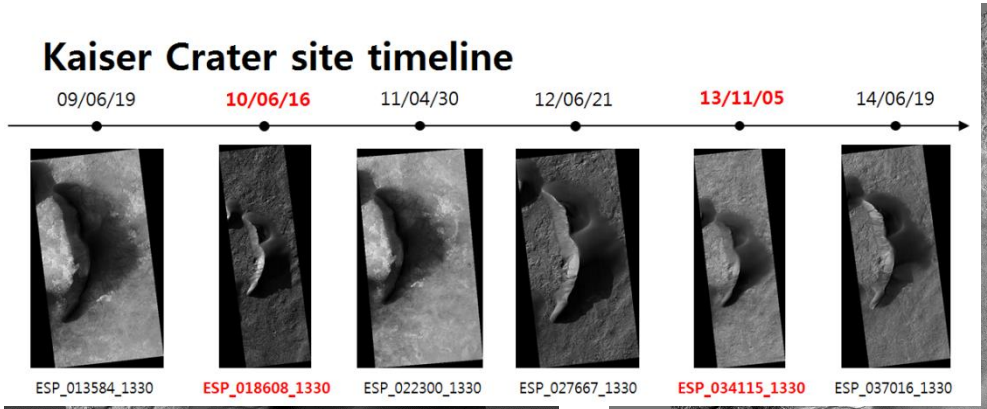
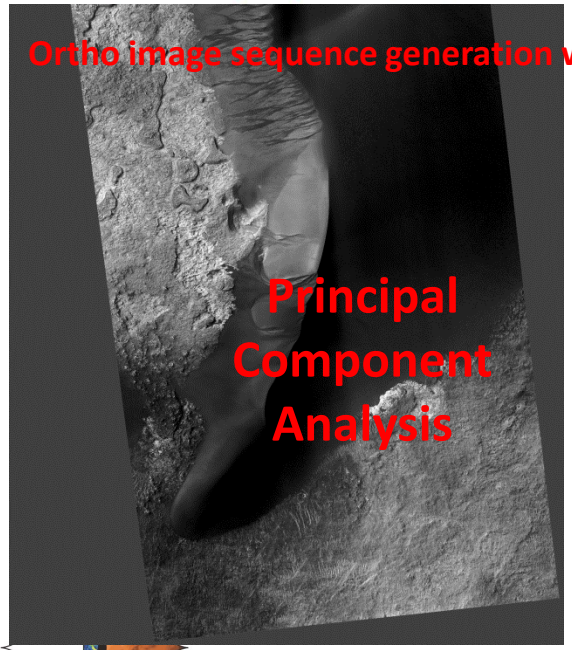
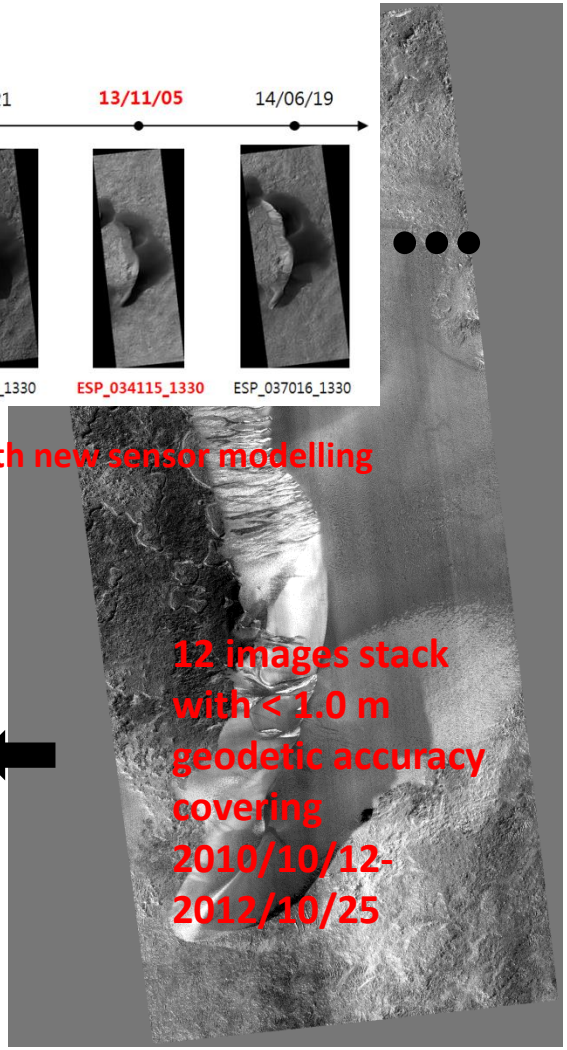
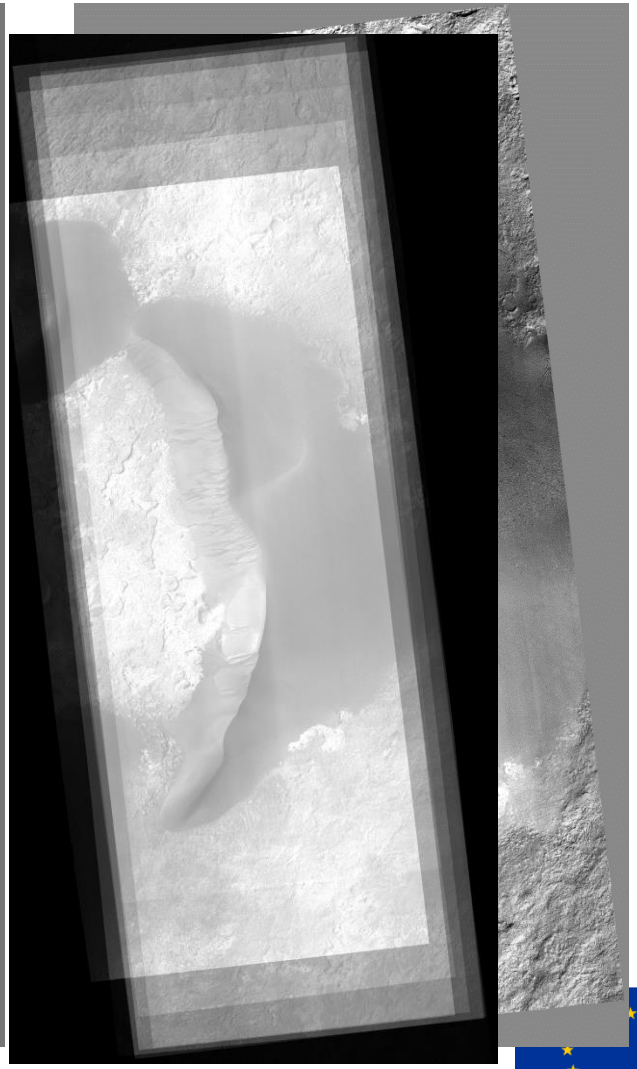
Stacked ortho image sequence and PCA



Ortho image sequence generation with new sensor modelling







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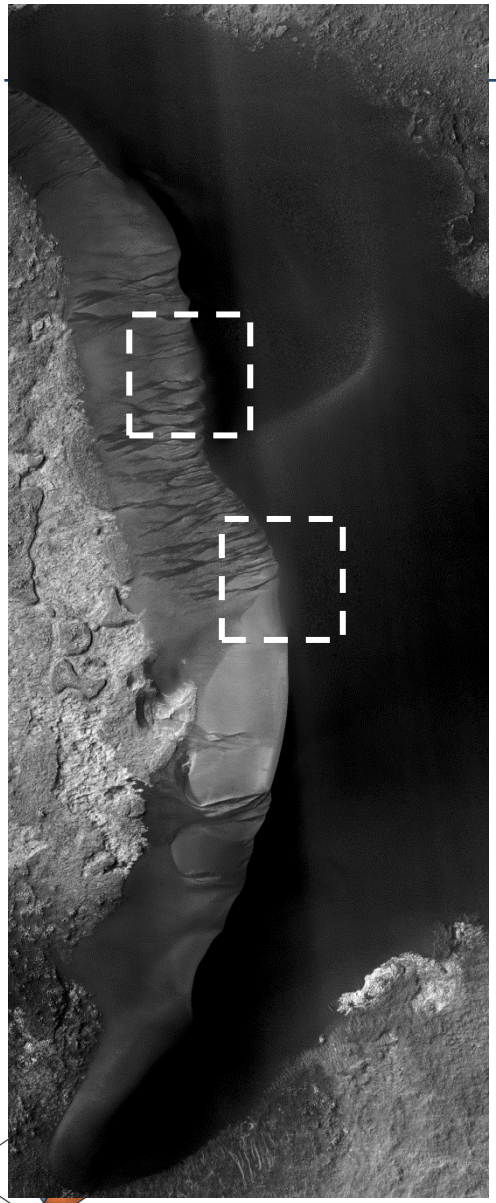

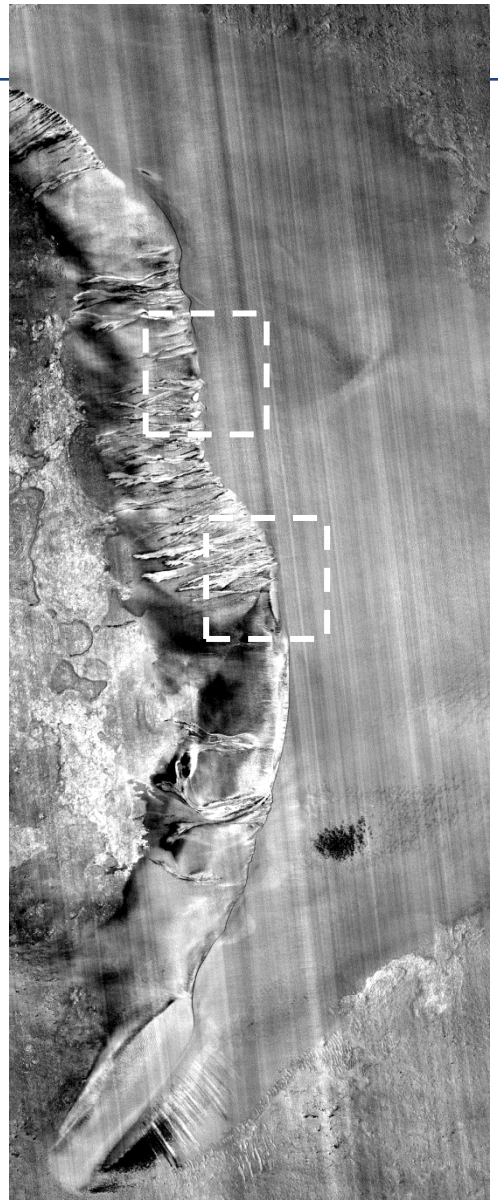

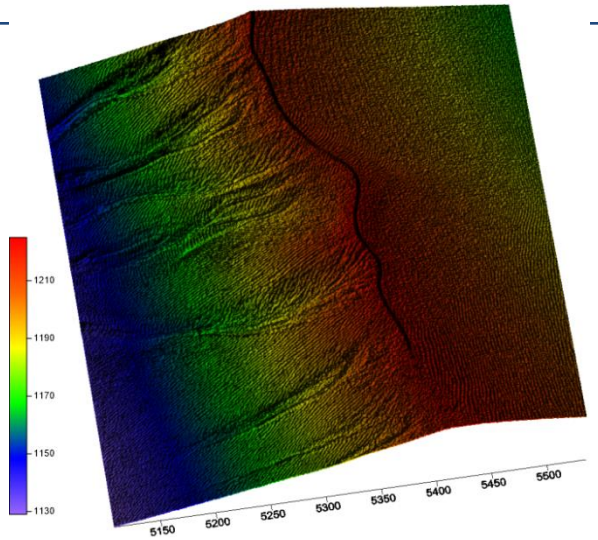

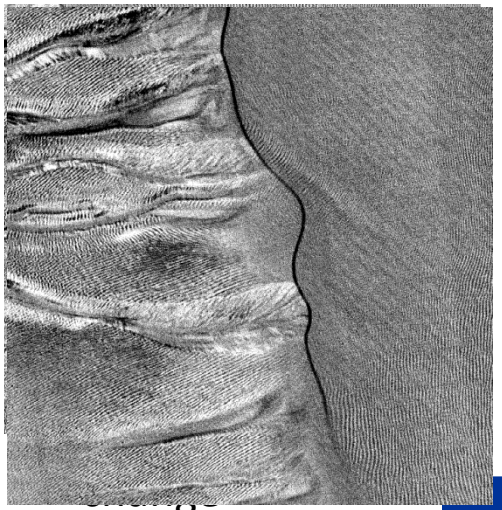

No crest change detected

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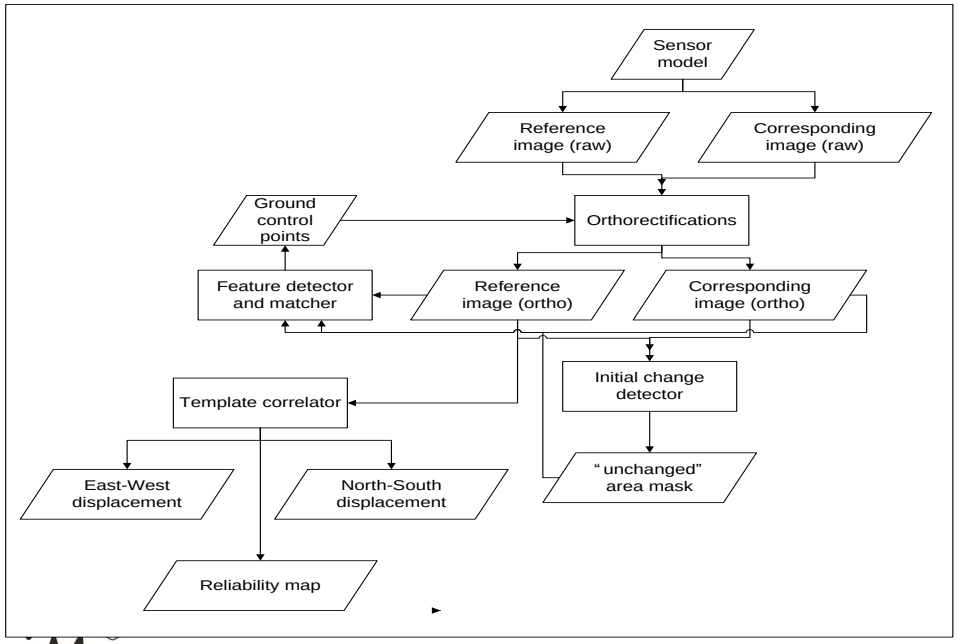
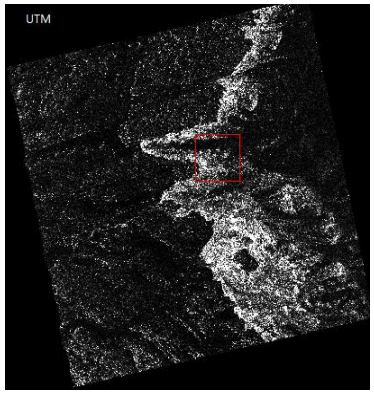
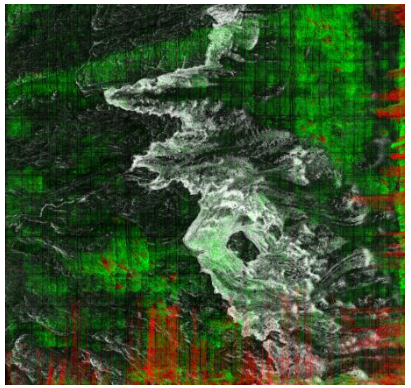
Proposed algorithms for automated registration

- **Conventional image registration algorithm doesn't make reliable measurements over the target images due to 1) the absence of high precision sub pixel registration ability; 2) algorithm failures over dark and monotonous dune textures.**
- **UoS algorithms replaced the measurement scheme based on a conventional image registration algorithm. The algorithmic steps of the new scheme are**
  - **(1) Coarse-to-Fine pyramidal measurement scheme employing image warping using an affine transformation**
  - **(2) Scale-invariant feature transform (SIFT) was introduced to define the target points for tracking.**
  - **(3) A Machine Vision algorithm using optical flow was introduced to make initial registrations.**
  - **(4) Adaptive Least Squares correlator was employed 1) to refine registration; 2) to calculate registration cost.**
  - **(5) Only reliable registration with sufficient matching cost value was delivered to the next pyramidal stage**







Base algorithms : UoS in-house S/W for Greenland glacier tracing Modified for a smooth surface

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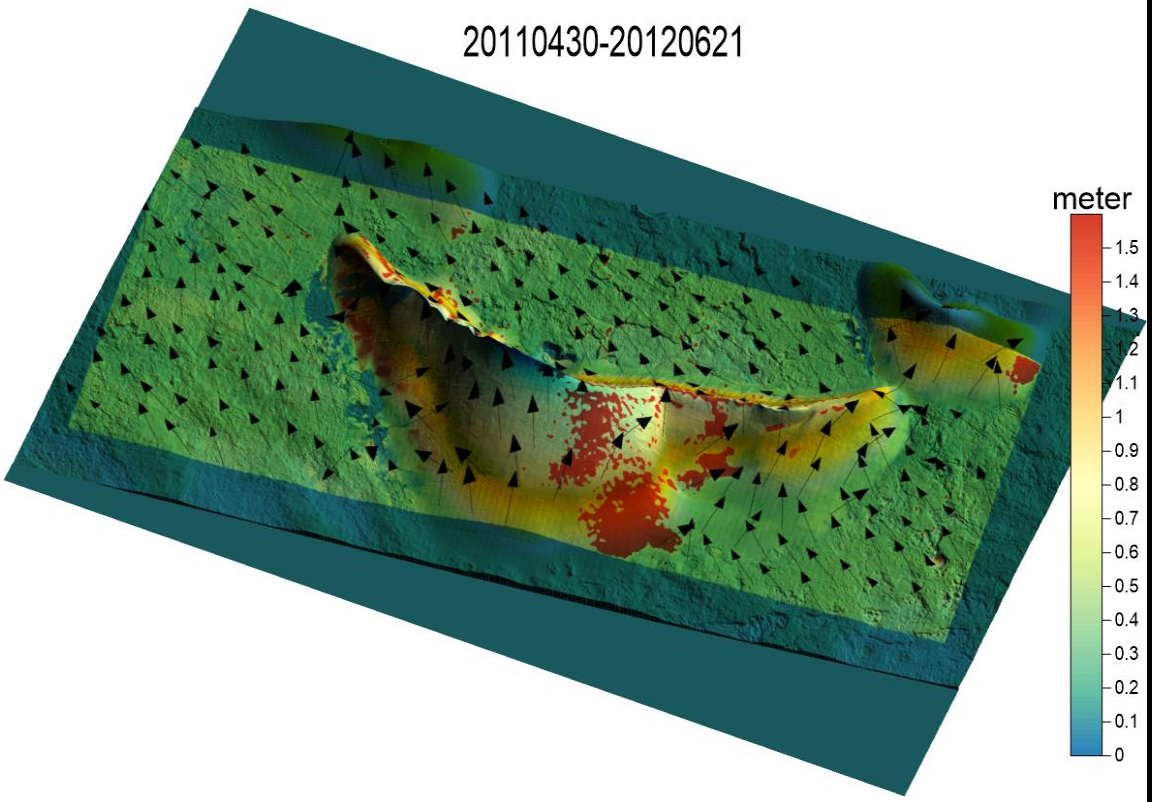
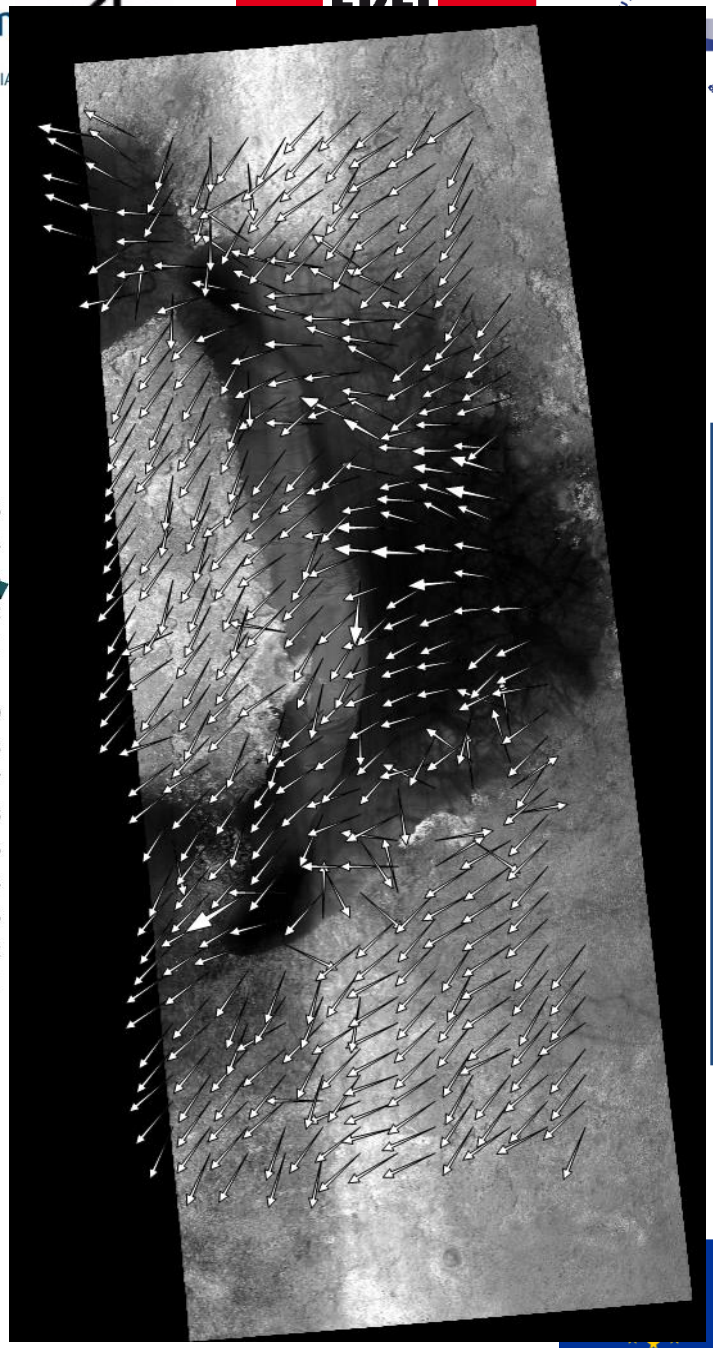
Outputs : Kaiser crater





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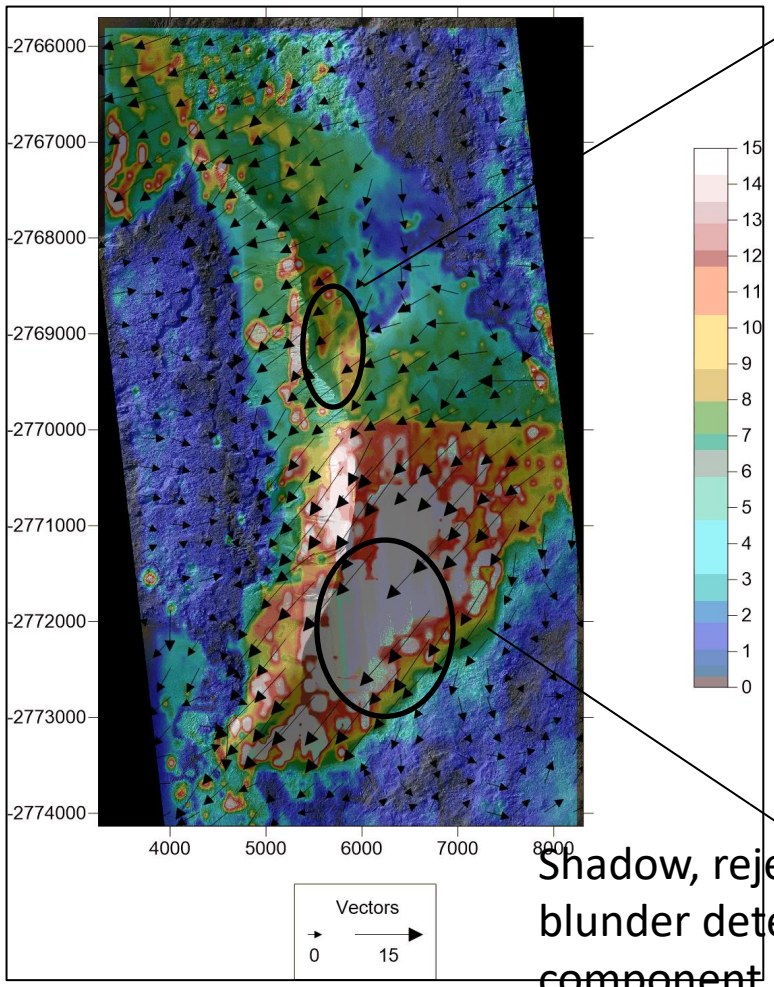
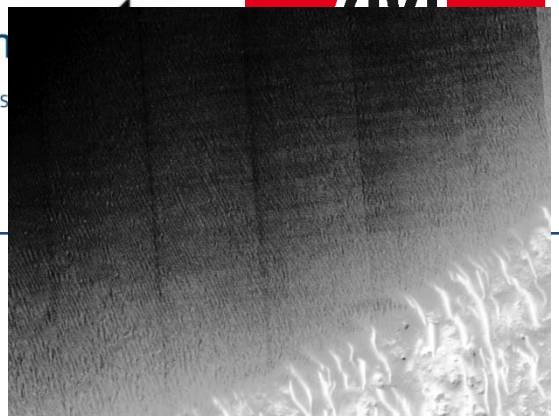


Osculation by Co2 frost

Shadow, rejected by blunder detection component
& Active seasonal CO2 gully networks



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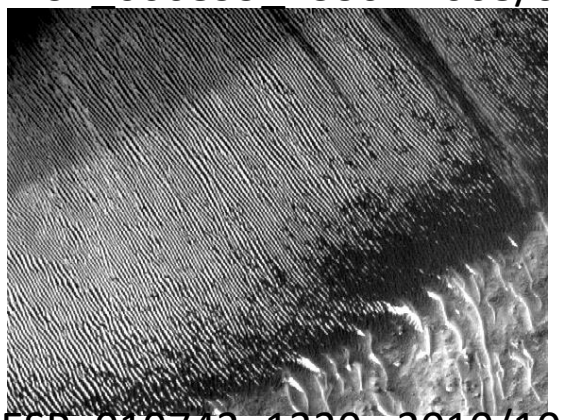

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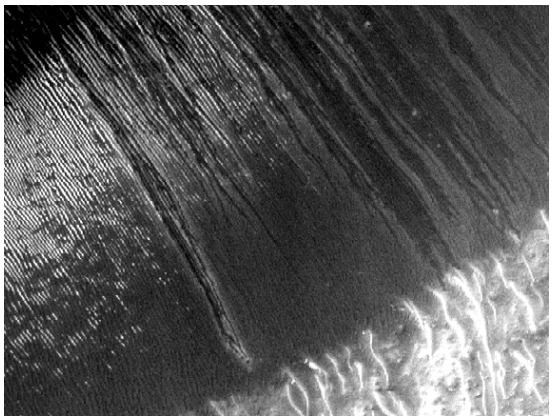

ESP_019953_1330 : 2010/10/29

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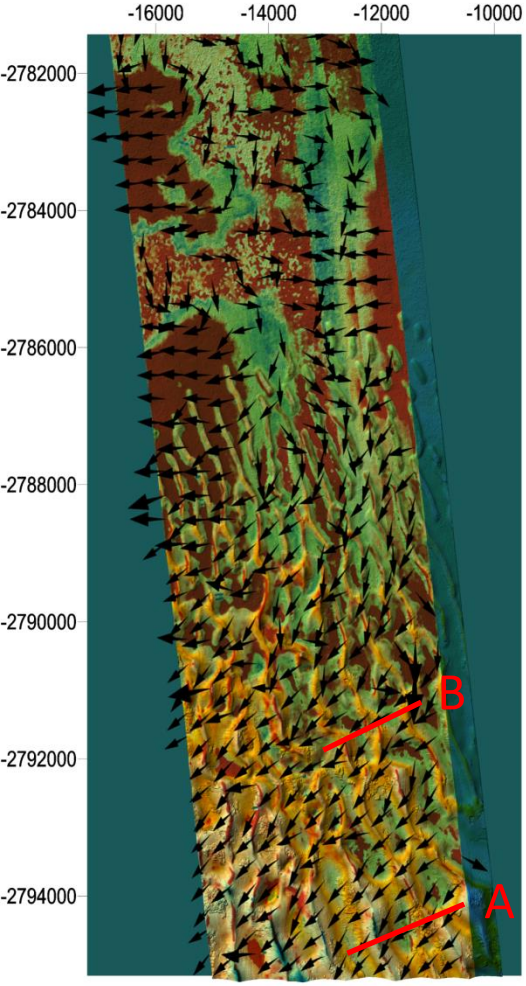
Output : Proctor



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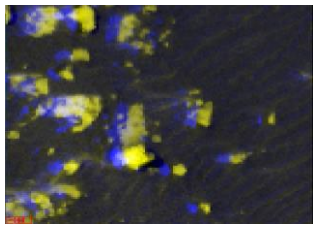
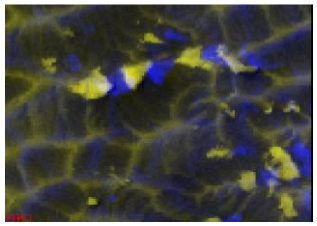
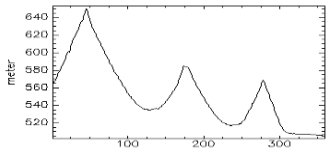
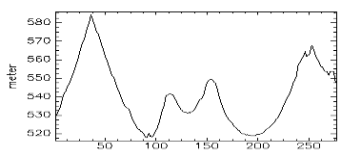






A



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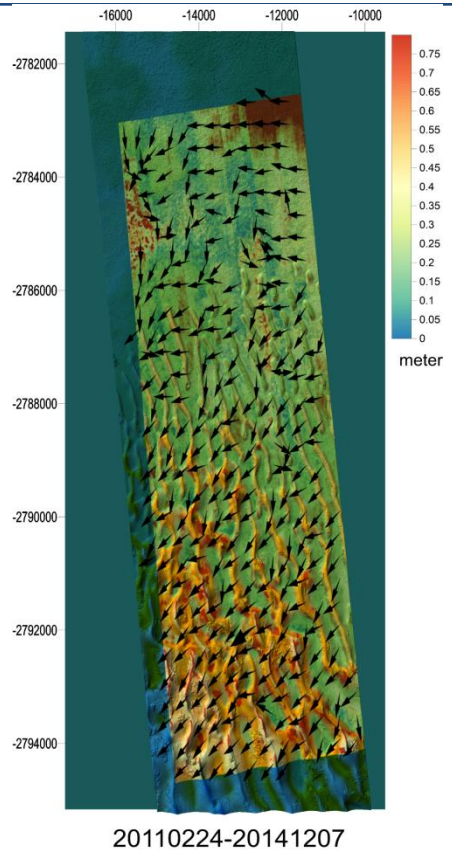

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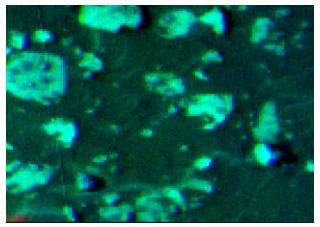

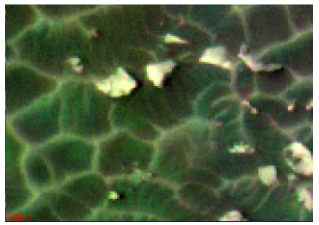

- Influenced by bad photogrammetric control
- Smaller migration speed than Kaiser

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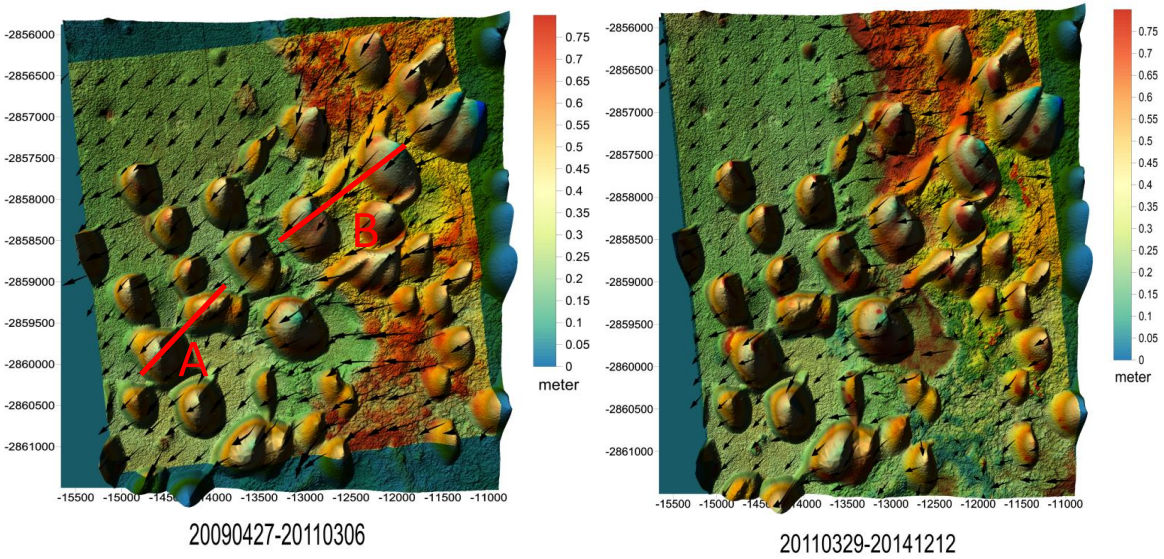
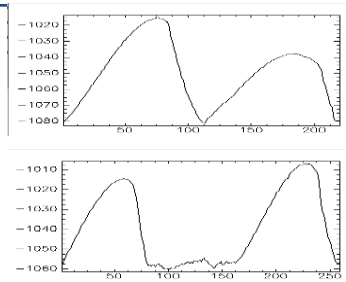
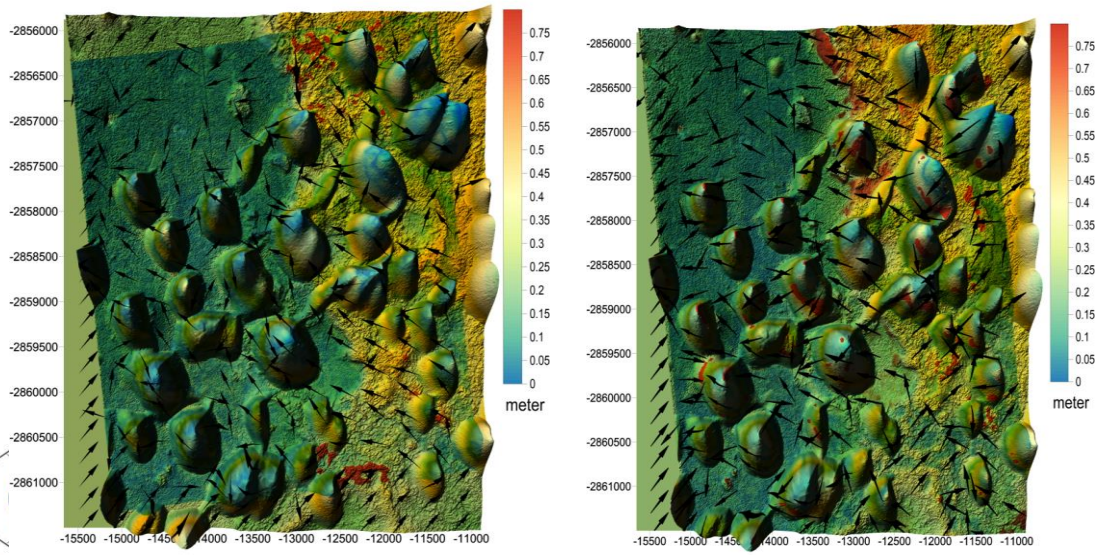
Outputs : Wirtz crater





- Very low mobility except the area effected by jitter
- The migrations in the opposite direction of the estimated slip side



- After applying offset (>0.3 pixel) value estimated from empty space.
- The displacement vectors represent Wirtz is a static dune field.

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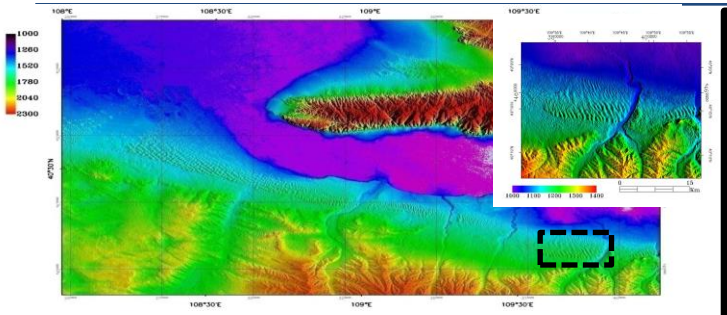
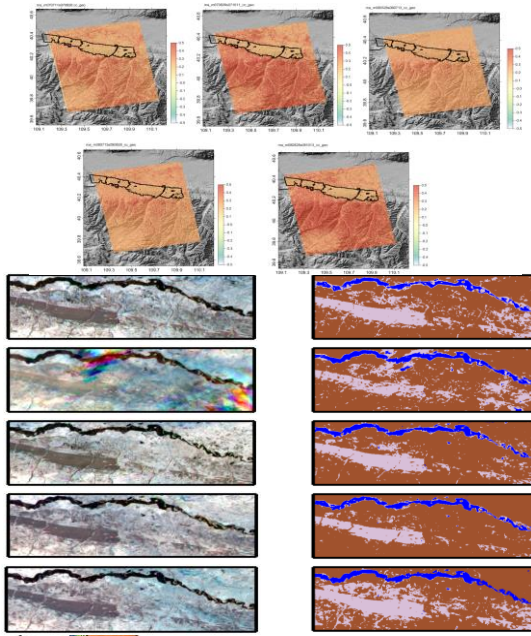
Potential application for terrestrial dune cases



Kubuchi/Badein Jaran Desert in North western China - United Nations Convention to Combat Desertification (UNCCD) test area



2005 NDAIs and traced dune

2006 NDAIs and traced dune (image corruption)

2008 NDAIs and traced dune

2010 NDAIs and traced dune

Multi View Angle & InSAR RS observation
Kim et al. 2014

- Dune tracing techniques by iMars will be applied to UVA photogrammetric observations during 2017-2018 (supported by UNCCD).
- UoS will report scientific outcomes in Sep/2017 UNCCD congress.
- Then combined with mid resolution space-borne sensing and passive ground ranging, the aeolian process will be more clearly identified. Possibly analogue study with Martian Dune on the circumstance of -30ºC in winter

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Conclusions

- The detected dune migration speed with the best possible photogrammetric adjustment is very small, close to static. Estimated maximum aeolian migration speed in test areas are << 1m/Earth year.
- It appears that the observed dune migrations are not genuine but mostly photogrammetric errors, if proper geodetic control is not applied.
- Illumination changes combining topographic reliefs, seasonal surface conditions might induce many “false dune migration” measurements.
- The moving directions of large slip faces correspond to the typical dune migration mechanism.
- These techniques will be applied to real world terrestrial environmental issues – in particular, combating desertification, thanks to the UNCCD.