PRESENTS

PolSARpro v6.0 (Biomass Edition)

POLARIMETRIC DATA FORMAT

Description

This help file describes the different and specific PolSARpro v6.x (Biomass Edition) compatible raw binary data formats.

PolSARpro v6.x (Biomass Edition) can process fully polarimetric or partially polarimetric data sets under many different formats.

A polarimetric data set is composed of Binary files characterized by a Configuration Text File and located in a given Data Directory.

Configuration Text File

A Configuration text file is automatically created by the different data processing applications proposed in PolSARpro and by any conversion from sensor specific format data.

PolSARpro offers the possibility to directly process polarimetric data binary files. In this case, users have to provide a configuration text file named config.txt and formatted as follows:

config.txt

```
Nrow
Image number of rows
---------
Ncol
Image number of columns
---------
PolarCase
monostatic or bistatic
---------
PolarType
full or pp1 or pp2 or pp3
```

Note : *PolSARpro is case sensitive*

Binary Data Files (1/2)

In order to be correctly interpreted by PolSARpro, binary data files have to be built according to a compatible format.

- **A Nrow x Ncol image is read by PolSARpro on a row by row basis, i.e. Ncol pixels are read in a single thread and are then assigned to one of the rows of a Nrow x Ncol matrix as shown in the following illustration.**

$$N_{ROW} \left\{ \underbrace{\begin{bmatrix} P_{1,1} & \cdots & P_{1,j} & \cdots & P_{1,Ncol} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ P_{i,1} & \cdots & P_{i,j} & \cdots & P_{1,Ncol} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ P_{Nrow,1} & \cdots & P_{Nrow,j} & \cdots & P_{Nrow,Ncol} \end{bmatrix}}_{N_{COL}} \right.$$

Binary Data Files (2/2)

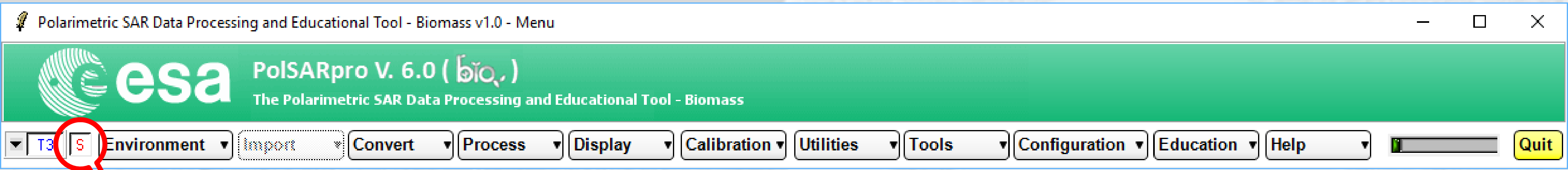
- **Binary data associated to real (not complex) variables are coded under the form of 4-bytes (i.e. 32 bits) float numbers.**
  A Nrow x Ncol image of a real variable (e.g T_{11}) contains Nrow*Ncol*4 bytes, i.e. Nrow*Ncol*32 bits.

- **Binary data associated to complex variables are coded under the form of interlaced 4-bytes float numbers representing real and imaginary parts.**
  A Nrow x Ncol image of a complex variable (e.g s_{11}) contains Nrow*Ncol*2*4 bytes, i.e. Nrow*Ncol*2*32 bits.

$$\left\{T_{i,1} \quad \cdots \quad T_{i,j} \quad \cdots \quad T_{i,Ncol}\right\}$$

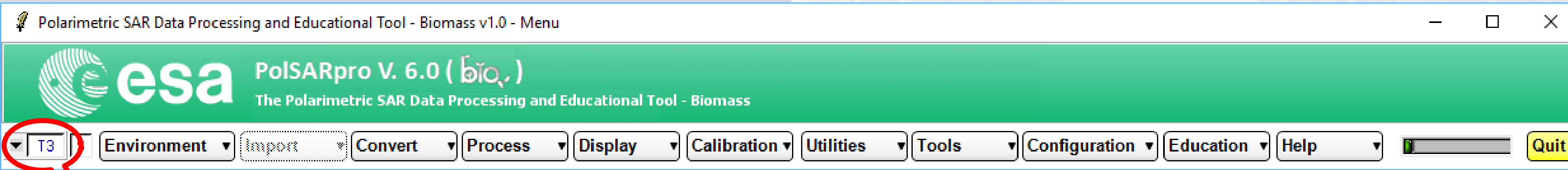
$$\left\{\Re\left(s_{i,1}\right), \quad \Im\left(s_{i,1}\right), \quad \cdots \quad \Re\left(s_{i,j}\right), \quad \Im\left(s_{i,j}\right), \quad \cdots \quad \Re\left(s_{i,Ncol}\right), \quad \Im\left(s_{i,Ncol}\right)\right\}$$

Schematic description of one row with Ncol real (T_{11}) or complex (S_{11}) elements

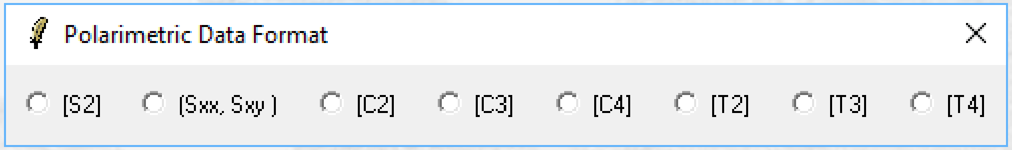


Active Program

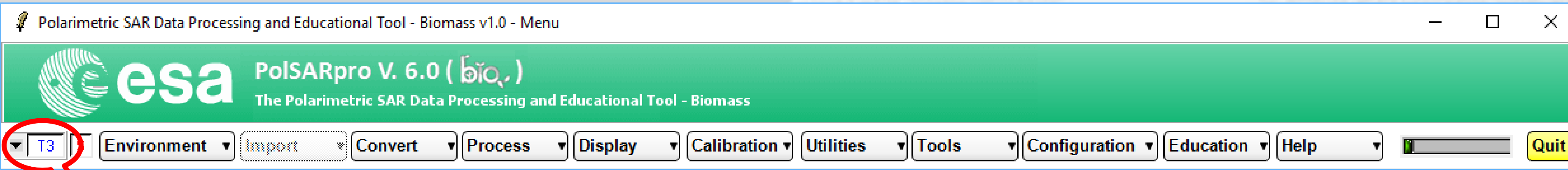
- **S : Single polarimetric data set (PolSAR mode)**
- **D : Dual polarimetric data sets (Single Baseline – Pol-InSAR mode)**
- **M : Multi polarimetric data sets (Time series – Pol-TimeSAR mode**
  Tomography – Pol-TomoSAR mode)



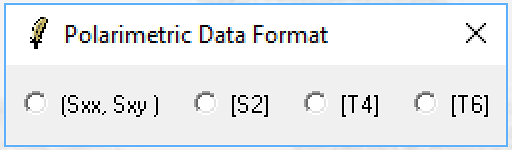
Active Data Format



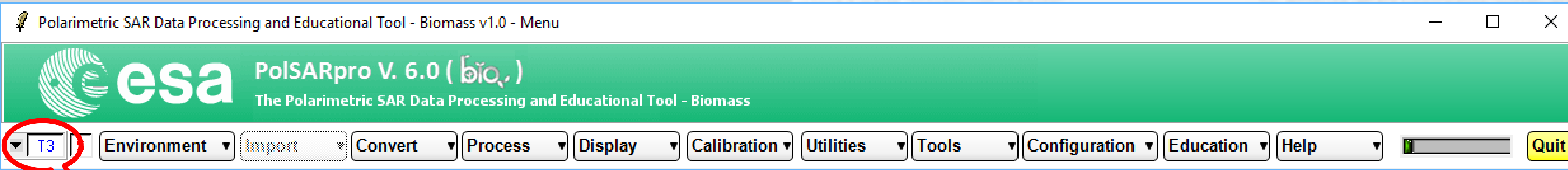
- **S : Single polarimetric data set (PolSAR mode)**
  - **[S2] : (2x2) complex Sinclair matrix**
  - **(Sxx, Sxy) : (2x1) dual-pol complex vector**
  - **[C2] : (2x2) dual-pol covariance [C2] matrix**
  - **[C3] : (3x3) full-pol covariance [C3] matrix**
  - **[C4] : (4x4) full-pol covariance [C4] matrix**
  - **[T2] : (2x2) dual-pol coherency [T2] matrix**
  - **[T3] : (3x3) full-pol coherency [T3] matrix**
  - **[T4] : (4x4) full-pol coherency [T4] matrix**



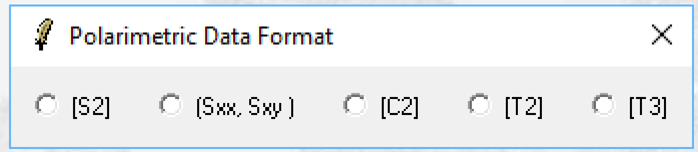
Active Data Format



- **D : Dual polarimetric data sets (Single Baseline – Pol-InSAR mode)**
  - **[S2] : (2x2) complex Sinclair matrix (Master / Slave)**
  - **(Sxx, Sxy) : (2x1) dual-pol complex vector (Master / Slave)**
  - **[T4] : (4x4) dual-pol coherency [T4] matrix (Master + Slave)**
  - **[T6] : (6x6) full-pol coherency [T6] matrix (master + Slave)**



Active Data Format



- **M : Multi polarimetric data sets (Time series – Pol-TimeSAR mode
  Tomography – Pol-TomoSAR mode)**
  - **[S2] : (2x2) complex Sinclair matrix**
  - **(Sxx, Sxy) : (2x1) dual-pol complex vector**
  - **[C2] : (2x2) dual-pol covariance [C2] matrix**
  - **[T3] : (3x3) full-pol coherency [T3] matrix**

(2x2) complex Sinclair $[S_2]$ matrix (1/2)

This matrix is a coherent polarimetric representation relating incident and scattered Jones vectors.

In a general case, it is composed of four complex elements and becomes symmetric in monostatic configurations.

$$[S_2] = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

The (2x2) complex Sinclair $[S_2]$ raw binary data files have to be located in the User Main Data Directory (MDD) and described by a configuration text file.

(2x2) complex Sinclair [S_2] matrix (2/2)

Contents of the User Main Data Directory (MDD) :

- **~ MDD / .**
- **~ MDD / ..**
- **~ MDD / config.txt**
- **~ MDD / s11.bin**
- **~ MDD / s12.bin**
- **~ MDD / s21.bin**
- **~ MDD / s22.bin**

Important Note : ***PolSARpro requires distinct s12.bin and s21.bin data files, even in monostatic configurations.***
Some polarimetric data sets only present a single cross-polarization channel, e.g. s12.bin. Users have then to create a second cross-polarization channel, e.g. copy s12.bin to s21.bin.

config.txt file :

- **PolarType = full**
- **If [S_2] matrix is symmetric (s12 = s21) : PolarCase = monostatic**
- **If [S_2] matrix is non symmetric (s12 != s21) : PolarCase = bistatic**

(3x3) coherency [T_3] matrix (1/2)

- This matrix is an incoherent polarimetric representation relating to second order statistics of scattering matrix elements.
- This matrix is hermitian semi-definite positive.
- This matrix is constructed from a three-element unitary target vector, obtained from the projection of a Sinclair matrix onto a reduced and modified Pauli spin matrix set. An outter product leads to the definition of the corresponding (3x3) Coherency matrix [T_3] relating to second order statistics.

$$\vec{k}_{3P} = \frac{1}{\sqrt{2}}\begin{bmatrix} S_{11}+S_{22} & S_{11}-S_{22} & S_{12}+S_{21} \end{bmatrix}^T$$

$$\Rightarrow \quad \left[T_3\right] = \left\langle \vec{k}_{3P} \cdot \vec{k}_{3P}^{T*} \right\rangle = \begin{bmatrix} T_{11} & T_{12} & T_{13} \\ T_{12}^* & T_{22} & T_{23} \\ T_{13}^* & T_{23}^* & T_{33} \end{bmatrix}$$

where < . > denotes for an eventual averaging operator.

(3x3) coherency [T_3] matrix (2/2)

The (3x3) coherency [T_3] raw binary data files have to be located in the User Main Data Directory (MDD) and described by a configuration text file.

Contents of the User Main Data Directory (MDD) :

- ~ MDD / .
- ~ MDD / ..
- ~ MDD / config.txt
- ~ MDD / T11.bin
- ~ MDD / T12_real.bin
- ~ MDD / T12_imag.bin
- ~ MDD / T13_real.bin
- ~ MDD / T13_imag.bin
- ~ MDD / T22.bin
- ~ MDD / T23_real.bin
- ~ MDD / T23_imag.bin
- ~ MDD / T33.bin

Note : ***Txy_real.bin and Txy_imag.bin denote respectively real and imaginary part of a coherency matrix complex element.***

config.txt file :

- **PolarType = full**
- **PolarCase = monostatic**

(4x4) coherency $[T_4]$ matrix (1/2)

- This matrix is an incoherent polarimetric representation relating to second order statistics of scattering matrix elements.
- This matrix is hermitian semi-definite positive.
- This matrix is constructed from a four-element unitary target vector, obtained from the projection of a Sinclair matrix onto a reduced and modified Pauli spin matrix set. An outter product leads to the definition of the corresponding (4x4) Coherency matrix $[T_4]$ relating to second order statistics.

$$\vec{k}_{4P} = \frac{1}{\sqrt{2}}\left[S_{11}+S_{22} \quad S_{11}-S_{22} \quad S_{12}+S_{21} \quad j\left(S_{12}-S_{21}\right) \right]^T$$

$$\Rightarrow \quad \left[T_4\right] = \left\langle \vec{k}_{4P} \cdot \vec{k}_{4P}^{T*} \right\rangle = \begin{bmatrix} T_{11} & T_{12} & T_{13} & T_{14} \\ T_{12}^* & T_{22} & T_{23} & T_{24} \\ T_{13}^* & T_{23}^* & T_{33} & T_{34} \\ T_{14}^* & T_{24}^* & T_{34}^* & T_{44} \end{bmatrix}$$

where < . > denotes for an eventual averaging operator.

(4x4) coherency $[T_4]$ matrix (2/2)

The (4x4) coherency $[T_4]$ raw binary data files have to be located in the User Main Data Directory (MDD) and described by a configuration text file.

Contents of the User Main Data Directory (MDD) :

- ~ MDD / .
- ~ MDD / ..
- ~ MDD / config.txt
- ~ MDD / T11.bin
- ~ MDD / T12_real.bin
- ~ MDD / T12_imag.bin
- ~ MDD / T13_real.bin
- ~ MDD / T13_imag.bin
- ~ MDD / T14_real.bin
- ~ MDD / T14_imag.bin
- ~ MDD / T22.bin
- ~ MDD / T23_real.bin
- ~ MDD / T23_imag.bin
- ~ MDD / T24_real.bin
- ~ MDD / T24_imag.bin
- ~ MDD / T33.bin
- ~ MDD / T34_real.bin
- ~ MDD / T34_imag.bin
- ~ MDD / T44.bin

Note : ***Txy_real.bin and Txy_imag.bin denote respectively real and imaginary part of a coherency matrix complex element.***

config.txt file :

- **PolarType = full**
- **PolarCase = bistatic**

(3x3) covariance $[C_3]$ matrix (1/2)

- **This matrix is an incoherent polarimetric representation relating to second order statistics of scattering matrix elements.**
- **This matrix is hermitian semi-definite positive.**
- **This matrix is constructed from a three-element unitary target vector, obtained from the projection of a Sinclair matrix onto a reduced and modified Lexicographic matrix set. An outter product leads to the definition of the corresponding (3x3) Covariance matrix $[C_3]$ relating to second order statistics.**

$$\vec{k}_{3L} = \begin{bmatrix} s_{11} & \sqrt{2}s_{12} & s_{22} \end{bmatrix}^T$$

$$\Rightarrow \begin{bmatrix} C_3 \end{bmatrix} = \left\langle \vec{k}_{3L} \cdot \vec{k}_{3L}^{T*} \right\rangle = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{12}^* & C_{22} & C_{23} \\ C_{13}^* & C_{23}^* & C_{33} \end{bmatrix}$$

where < . > denotes for an eventual averaging operator.

(3x3) covariance [C_3] matrix (2/2)

The (3x3) covariance [C_3] raw binary data files have to be located in the User Main Data Directory (MDD) and described by a configuration text file.

Contents of the User Main Data Directory (MDD) :

- ~ MDD / .
- ~ MDD / ..
- ~ MDD / config.txt
- ~ MDD / C11.bin
- ~ MDD / C12_real.bin
- ~ MDD / C12_imag.bin
- ~ MDD / C13_real.bin
- ~ MDD / C13_imag.bin
- ~ MDD / C22.bin
- ~ MDD / C23_real.bin
- ~ MDD / C23_imag.bin
- ~ MDD / C33.bin

Note : ***Cxy_real.bin and Cxy_imag.bin denote respectively real and imaginary part of a covariance matrix complex element.***

config.txt file :

- **PolarType = full**
- **PolarCase = monostatic**

(4x4) covariance [C_4] matrix (1/2)

- This matrix is an incoherent polarimetric representation relating to second order statistics of scattering matrix elements.
- This matrix is hermitian semi-definite positive.
- This matrix is constructed from a four-element unitary target vector, obtained from the projection of a Sinclair matrix onto a reduced and modified Lexicographic matrix set. An outter product leads to the definition of the corresponding (4x4) Covariance matrix [C_4] relating to second order statistics.

$$\vec{k}_{4L} = \begin{bmatrix} S_{11} & S_{12} & S_{21} & S_{22} \end{bmatrix}^T$$

$$\Rightarrow \quad [C_4] = \left\langle \vec{k}_{4L} \cdot \vec{k}_{4L}^{T*} \right\rangle = \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} \\ C_{12}^* & C_{22} & C_{23} & C_{24} \\ C_{13}^* & C_{23}^* & C_{33} & C_{34} \\ C_{14}^* & C_{24}^* & C_{34}^* & C_{44} \end{bmatrix}$$

where < . > denotes for an eventual averaging operator.

(4x4) covariance [C_4] matrix (2/2)

The (4x4) covariance [C_4] raw binary data files have to be located in the User Main Data Directory (MDD) and described by a configuration text file.

Contents of the User Main Data Directory (MDD) :

- ~ MDD / .
- ~ MDD / ..
- ~ MDD / config.txt
- ~ MDD / C11.bin
- ~ MDD / C12_real.bin
- ~ MDD / C12_imag.bin
- ~ MDD / C13_real.bin
- ~ MDD / C13_imag.bin
- ~ MDD / C14_real.bin
- ~ MDD / C14_imag.bin
- ~ MDD / C22.bin
- ~ MDD / C23_real.bin
- ~ MDD / C23_imag.bin
- ~ MDD / C24_real.bin
- ~ MDD / C24_imag.bin
- ~ MDD / C33.bin
- ~ MDD / C34_real.bin
- ~ MDD / C34_imag.bin
- ~ MDD / C44.bin

Note : *Cxy_real.bin and Cxy_imag.bin denote respectively real and imaginary part of a coherency matrix complex element.*

config.txt file :

- **PolarType = full**
- **PolarCase = bistatic**

(2x1) dual-polarimetric (Sxx, Sxy) vector (1/2)

This vector is a coherent polarimetric representation of a scattered Jones vector.

It is composed of two complex elements.

There exist three different combinations which are the following :

- **Partial polarimetry mode 1 (pp1) : (Sxx, Sxy) ≡ {s11, s21}**
- **Partial polarimetry mode 2 (pp2) : (Sxx, Sxy) ≡ {s12, s22}**
- **Partial polarimetry mode 3 (pp3) : (Sxx, Sxy) ≡ {s11, s22}**

The (2x1) complex (Sxx, Sxy) raw binary data files have to be located in the User Main Data Directory (MDD) and described by a configuration text file.

(2x1) dual-polarimetric (Sxx, Sxy) vector (2/2)

Contents of the User Main Data Directory (MDD) :

pp1 mode :
- ~ MDD / .
- ~ MDD / ..
- ~ MDD / config.txt
- ~ MDD / s11.bin
- ~ MDD / s21.bin

pp2 mode :
- ~ MDD / .
- ~ MDD / ..
- ~ MDD / config.txt
- ~ MDD / s12.bin
- ~ MDD / s22.bin

pp3 mode :
- ~ MDD / .
- ~ MDD / ..
- ~ MDD / config.txt
- ~ MDD / s11.bin
- ~ MDD / s22.bin

config.txt file :
- **PolarCase = monostatic**
- **PolarType = pp1 or pp2 or pp3**

(2x2) dual-polarimetric covariance [C_2] matrix (1/2)

- **This matrix is an incoherent polarimetric representation relating to second order statistics of a Jones vector.**
- **This matrix is hermitian semi-definite positive.**

- **This matrix is constructed from a two-element Jones vector and an outter product leads to the definition of the corresponding (2x2) Covariance matrix [C_2] relating to second order statistics.**

$$\vec{k}_{2L} = \begin{bmatrix} s_{xx} & s_{xy} \end{bmatrix}^T$$

$$\Rightarrow \quad \left[C_2\right] = \left\langle \vec{k}_{2L} \cdot \vec{k}_{2L}^{T*} \right\rangle = \begin{bmatrix} C_{11} & C_{12} \\ C_{12}^* & C_{22} \end{bmatrix}$$

where < . > denotes for an eventual averaging operator.

(2x2) dual-polarimetric covariance [C_2] matrix (2/2)

The (2x2) covariance [C_2] raw binary data files have to be located in the User Main Data Directory (MDD) and described by a configuration text file.

Contents of the User Main Data Directory (MDD) :

- ~ MDD / .
- ~ MDD / ..
- ~ MDD / config.txt
- ~ MDD / C11.bin
- ~ MDD / C12_real.bin
- ~ MDD / C12_imag.bin
- ~ MDD / C22.bin

Note : ***Cxy_real.bin and Cxy_imag.bin denote respectively real and imaginary part of a covariance matrix complex element.***

config.txt file :

- **PolarCase = monostatic**
- **PolarType = pp1 or pp2 or pp3**

Dual-polarimetric Pol-InSAR data format

Master MDD $\left\{ s_{xx}^{M} \quad s_{xy}^{M} \right\}$

Slave MDD $\left\{ s_{xx}^{S} \quad s_{xy}^{S} \right\}$

$$\vec{k}_{2P}^{M} = \frac{1}{\sqrt{2}} \left[s_{xx}^{M} - s_{xy}^{M} \quad s_{xx}^{M} + s_{xy}^{M} \right]^{T}$$

$$\vec{k}_{2P}^{S} = \frac{1}{\sqrt{2}} \left[s_{xx}^{S} - s_{xy}^{S} \quad s_{xx}^{S} + s_{xy}^{S} \right]^{T}$$

$$\vec{k}_{4P}^{M+S} = \left[\vec{k}_{2P}^{M} \quad \vec{k}_{2P}^{S} \right]^{T}$$

Master MDD_Slave MDD

$$\Rightarrow \left[T_{4}^{M+S} \right] = \left\langle \vec{k}_{4P}^{M+S} \cdot \left(\vec{k}_{4P}^{M+S} \right)^{T*} \right\rangle = \begin{bmatrix} T_{11}^{M} & T_{12}^{M} & \Omega_{11} & \Omega_{12} \\ T_{21}^{M} & T_{22}^{M} & \Omega_{21} & \Omega_{22} \\ \Omega_{11}^{*} & \Omega_{12}^{*} & T_{11}^{S} & T_{12}^{S} \\ \Omega_{21}^{*} & \Omega_{22}^{*} & T_{21}^{S} & T_{22}^{S} \end{bmatrix}$$

where < . > denotes for an eventual averaging operator.

Full-polarimetric Pol-InSAR data format (1/2)

Master MDD $\left[S_2^M\right]=\begin{bmatrix} s_{11}^M & s_{12}^M \\ s_{21}^M & s_{22}^M \end{bmatrix}$

Slave MDD $\left[S_2^S\right]=\begin{bmatrix} s_{11}^S & s_{12}^S \\ s_{21}^S & s_{22}^S \end{bmatrix}$

$$\vec{k}_{3P}^{M}=\frac{1}{\sqrt{2}}\left[s_{11}^M+s_{22}^M \quad s_{11}^M-s_{22}^M \quad s_{12}^M+s_{21}^M\right]^T$$

$$\vec{k}_{3P}^{S}=\frac{1}{\sqrt{2}}\left[s_{11}^S+s_{22}^S \quad s_{11}^S-s_{22}^S \quad s_{12}^S+s_{21}^S\right]^T$$

$$\vec{k}_{6P}^{M+S}=\left[\vec{k}_{3P}^{M} \quad \vec{k}_{3P}^{S}\right]^T$$

where < . > denotes for an eventual averaging operator.

Full-polarimetric Pol-InSAR data format (2/2)

$$\vec{k}_{6P}^{M+S} = \left[\vec{k}_{3P}^{M} \quad \vec{k}_{3P}^{S} \right]^T$$

Master MDD_Slave MDD

$$\Rightarrow \quad \left[T_6^{M+S} \right] = \left\langle \vec{k}_{6P}^{M+S} \cdot \left(\vec{k}_{6P}^{M+S} \right)^{T*} \right\rangle = \left[\begin{array}{ccc|ccc} T_{11}^M & T_{12}^M & T_{13}^M & \Omega_{11} & \Omega_{12} & \Omega_{13} \\ T_{21}^M & T_{22}^M & T_{23}^M & \Omega_{21} & \Omega_{22} & \Omega_{23} \\ T_{31}^M & T_{32}^M & T_{33}^M & \Omega_{31} & \Omega_{32} & \Omega_{33} \\ \hline \Omega_{11}^* & \Omega_{12}^* & \Omega_{13}^* & T_{11}^S & T_{11}^S & T_{11}^S \\ \Omega_{21}^* & \Omega_{22}^* & \Omega_{23}^* & T_{11}^S & T_{11}^S & T_{11}^S \\ \Omega_{31}^* & \Omega_{32}^* & \Omega_{33}^* & T_{11}^S & T_{11}^S & T_{11}^S \end{array} \right]$$

where < . > denotes for an eventual averaging operator.

Questions ?